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**DISENTANGLING THE REPRESENTATIVENESS HEURISTIC FROM  
THE AVAILABILITY HEURISTIC**

**DOUTORAMENTO EM PSICOLOGIA**

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## **Abstract**

Most judgments, predictions and decisions rely on simplifying reasoning heuristics, such as representativeness and availability heuristics. Representativeness heuristic relies on a judgment of similarity between a categorical prototype and a target. Availability heuristic relies on the accessibility of instances. A crucial assumption of Heuristics and Biases research program (Tversky & Kahneman, 1974) was that systematic and characteristic biases were unmistakably associated with each heuristic. Unfortunately, often the same biases can be explained by different heuristics (e.g., Anderson, 1990; Gigerenzer, 1991). This problem is particularly striking in the case of availability and representativeness. The main goal of this dissertation is to conceptually clarify and empirically disentangle these heuristics, thus defining conditions for the use of one or the other. This dissertation explores three variables that have the potential to determine when people will use representativeness or availability: the level of construal, the computational speed of the heuristics, and directional motivation.

The first empirical chapter (Chapter II) explores whether the representativeness heuristic relies on more abstract information than the availability heuristic, and uses the construal level theory (e.g., Trope & Liberman, 2000) as a framework to explore and manipulate different levels of abstraction. Chapters III and IV explore whether representativeness heuristic takes longer to compute using a paradigm about predictions of binary random events, where both heuristics can be applied in the same judgment. The last empirical chapter (Chapter V) explores the role of directional motivation on the heuristic processes. The motivation to observe a certain outcome should affect people's representation of a target event, and consequently lead to self-serving predictions. The role of directional motivation is thus discussed as a variable that could be used in order to determine the use representativeness or availability heuristic. The consequences of

the proposed differences between representativeness and availability, for psychological models of judgment and decision making are discussed.

## **Resumo**

Muitos julgamentos, previsões e decisões são tomadas com base em heurísticas de julgamento como as heurísticas da representatividade e da disponibilidade. A heurística da representatividade baseia-se num julgamento de semelhança entre um protótipo e o alvo. A heurística da disponibilidade baseia-se na acessibilidade de ocorrências específicas. Um ponto essencial do programa Heurísticas e Enviesamentos (Tversky & Kahneman, 1974) seria que enviesamentos específicos e sistemáticos estariam inequivocamente associados a diferentes heurísticas. Infelizmente, muitas vezes o mesmo enviesamento poderia ser explicado por diferentes heurísticas. Este problema é particularmente grave no caso da representatividade e da disponibilidade. O objectivo desta tese é clarificar e dissociar empiricamente estas heurísticas, definindo, assim, condições para o uso de uma ou da outra. Esta tese explora três variáveis que poderão ajudar a determinar quando usamos a heurística da representatividade ou da disponibilidade: nível de abstracção; velocidade computacional e motivação direccional.

O primeiro capítulo empírico (Capítulo II) explora se a heurística da representatividade depende de informação mais abstracta que a heurística da disponibilidade, partindo da “construal level theory” (e.g., Trope & Liberman, 2000) para explorar e manipular níveis de abstracção. Os Capítulos III e IV exploram se a heurística da representatividade demora mais tempo a ser computada que a heurística da disponibilidade quando ambas as heurísticas podem ser aplicadas a uma tarefa de previsão binária de eventos aleatórios. O Capítulo V explora o papel da motivação para observar um resultado nos processos heurísticos. O desejo de observar determinado resultado deverá afectar a representação dos eventos e levar a prever o resultado que se deseja observar. O potencial papel da motivação direccional na determinação do uso das heurísticas da representatividade ou da disponibilidade é discutido.

## **Resumo Alargado**

No início da década de 70, Tversky e Kahneman (1974) desenvolveram uma abordagem de investigação que veio alterar o rumo da investigação em julgamento e tomada de decisão. No seu programa de investigação “heurísticas e enviesamentos”, os investigadores tinham como principal objectivo compreender os processos cognitivos que estavam na origem do julgamento humano. Tversky e Kahneman sugeriram que, em condições de incerteza, os indivíduos não fazem uma computação de acordo com as teorias de probabilidade e estatística. Em vez disso, parecem substituir o atributo de um alvo, que é desconhecido ou difícil de aceder, por um atributo heurístico. Assim, a complexidade do cálculo de probabilidades e da estimativa de valores é reduzida a computações mais simples (Kahneman & Frederick, 2002). Duas heurísticas revelaram-se particularmente importantes para realizar previsões e fazer estimativas de probabilidade, as heurísticas da representatividade e da disponibilidade.

A heurística da representatividade pressupõe que os julgamentos são feitos com base na semelhança entre um alvo e um protótipo da categoria de eventos em avaliação, o que implica a substituição de um evento alvo por um protótipo, e a substituição da probabilidade do evento pelo julgamento de representatividade.

A heurística da disponibilidade pressupõe que os julgamentos de probabilidade se baseiam na facilidade com que determinadas instâncias do evento surgem em mente.

Estas duas definições são claramente distintas; no entanto, as heurísticas da representatividade e da disponibilidade podem muitas vezes ser aplicadas à mesma tarefa, e podem ser usadas para explicar ou prever o mesmo evento (e.g., Anderson, 1990; Gigerenzer, 1991). Ou seja, não é claro que processos cognitivos estão subjacentes a estas heurísticas, como é que estas se relacionam entre si, e que condições facilitam o uso de uma ou de outra heurística. Na verdade, importa notar que muita da

investigação recente em tomada de decisão seguiu um caminho diferente, focando-se em explorar a existência de diferenças qualitativas entre julgamentos intuitivos que usam heurísticas e julgamentos regulados por raciocínio deliberativo e analítico (e.g., Evans & Stanovich, 2013; Kahneman & Frederick, 2005; Kruglansky & Gigerenzer, 2011).

Esta dissertação tem como objectivo trazer de volta a importância explicativa e preditiva destas diferentes heurísticas. Por conseguinte, esta dissertação pretende distinguir as heurísticas da representatividade e da disponibilidade a nível conceptual e empírico, assim como propor que condições levam ao uso de uma ou outra heurística.

Especificamente, esta dissertação propõe, e explora, duas diferenças cognitivas subjacentes à representatividade e à disponibilidade: diferenças no nível de abstracção, e diferenças relativas à velocidade de processamento de cada mecanismo. Adicionalmente, é explorado o papel da direcção motivacional nestes mecanismos heurísticos. Estas três variáveis – nível de abstracção, velocidade de processamento, e direcção motivacional – sugerem condições que vão favorecer o uso da heurística de representatividade ou da heurística de disponibilidade.

Primeiro, a presente dissertação defende que os processos cognitivos subjacentes ao uso da heurística da representatividade são geralmente mais abstractos do que os processos subjacentes à heurística da disponibilidade. Por um lado, a representatividade foi definida como sendo dependente de informação categórica abstracta, e pressupõe abstractos julgamentos de semelhança. Por outro lado, a disponibilidade baseia-se na acessibilidade de instâncias específicas e concretas. Baseado na teoria dos níveis de construção (e.g., Trope & Liberman, 2000), o primeiro artigo empírico desta dissertação sugere que os julgamentos baseados na representatividade são facilitados em condições que induzem um foco em processos e informação mais abstractos; e que os julgamentos

feitos por disponibilidade parecem ser facilitados quando são induzidos *mindsets* concretos. Por isto, conclui-se que o nível de abstracção do indivíduo perante uma situação de decisão parece ser uma condição importante para o uso da heurística representatividade ou da heurística da disponibilidade.

Em seguida, a presente dissertação defende que a computação de um julgamento por representatividade deve demorar mais tempo do que computar um julgamento pela heurística da disponibilidade, pois os processos cognitivos subjacentes são mais complexos na primeira do que na segunda. A representatividade pressupõe um processo de substituição em duas etapas: 1) adquirir uma representação abstracta do evento, seguida da 2) comparação desta representação com o alvo (Kahneman & Frederick, 2002, 2005). Pelo contrário, julgamentos feitos por disponibilidade podem basear-se directamente na acessibilidade das instâncias do evento, o que implica um simples processo de substituição com apenas uma etapa (Kahneman & Frederick, 2002, 2005). Neste sentido, prevê-se que um julgamento por representatividade demore mais tempo a ser computado do que um julgamento por disponibilidade.

Uma tarefa de previsão binária de eventos aleatórios permite testar esta hipótese. Neste tipo de paradigma, os participantes mostram uma tendência prever o fim de uma sequência de repetições (falácia do jogador), um padrão de resposta atribuído à heurística de representatividade (Tversky & Kahneman, 1971). No entanto, à medida que as repetições numa sequência ocorrem, o resultado repetido torna-se altamente acessível, pelo que um julgamento feito por disponibilidade, deve prever a continuação das repetições. Manipulações de pressão temporal aumentam as respostas de continuação, assim como a apresentação subliminar da sequência, reverte o efeito típico de falácia do jogador, que se manifesta em condições de não-sobrecarga cognitiva.

Deste modo, a imposição de constrangimentos temporais ao processamento da sequência e do julgamento, parecem impedir a computação da heurística da representatividade. No entanto, a heurística da disponibilidade parece não ser afectada por estas manipulação, pelo que, nestas condições, será mais provável fazer julgamentos por disponibilidade.

Por fim, esta dissertação defende que a direcção motivacional, isto é, a motivação para observar um determinado resultado em vez de outro, pode ser uma variável importante para prever o resultado de um julgamento e identificar o processo heurístico subjacente a essa mesma decisão.

A literatura mostra que a direcção motivacional guia as previsões dos indivíduos no sentido daquilo que desejam, mas que também tem impacto nos processos cognitivos mais implícitos (e.g., Molden & Higgins, 2005). Não só foi demonstrado que os indivíduos conseguem usar selectivamente estratégias mais ou menos complexas de forma a ir ao encontro do resultado desejado (e.g., Mata et al., 2013); mas que a motivação direccional também parece ter um impacto mais implícito, ao aumentar a acessibilidade da informação congruente com o resultado desejado (e.g., Kunda, 1990).

Deste modo, hipotetiza-se que a motivação direccional deve afectar julgamentos baseados na heurística da disponibilidade, mas também os que se baseiam na heurística de representatividade. Em última análise, quando o uso de cada uma das heurísticas, representatividade e disponibilidade, leva a resultados diferentes para o mesmo problema, a manipulação da direcção motivacional pode influenciar o uso de uma heurística em detrimento da outra. O quarto artigo empírico explora especificamente como a motivação direccional pode afectar a heurística da representatividade. Neste artigo, é discutido que a representação de um alvo para computar a heurística da representatividade vai depender do resultado que é mais favorável para o indivíduo. Em

tarefas de previsão de eventos binários, a intencionalidade percebida no agente que está a realizar a sequência de repetições influencia se o evento é percebido como tendo um padrão de sequências de repetições ou um padrão de alternância (Caruso et al., 2010).

No quarto artigo desta dissertação foi verificado que a motivação direccional leva a prever o resultado desejado, independentemente de implicar continuar ou alternar a sequência de repetições. Mais importante, este efeito mostrou ser mediado pelas representações que os participantes fazem acerca do evento. Ou seja, a motivação afecta a avaliação que os participantes fazem da responsabilidade que o agente da sequência tem para a previsão, o que afecta a expectativa acerca da tendência do evento para gerar repetições, o que consequentemente influencia as previsões dos participantes acerca da continuação, ou não, da sequência.

No conjunto dos quatro trabalhos empíricos, esta dissertação consiste numa tentativa de clarificar as diferenças cognitivas entre a representatividade e a disponibilidade, e propõe quais as condições e circunstâncias que podem levar ao uso de uma ou de outra heurística. A heurística da representatividade parece ser mais abstracta e demorar mais tempo a ser computada. Adicionalmente, a motivação direccional parece afectar a forma como a representatividade é usada, sugerindo que é uma condição potencialmente importante para o uso discriminado de uma ou de outra heurística.

Os resultados apresentados nesta dissertação têm implicações importantes para a distinção empírica e conceptual das heurísticas da representatividade e da disponibilidade. Estes resultados são, assim, o ponto de partida para a discussão acerca da relação entre estas duas heurísticas. Esta dissertação contribui, ainda, com a proposta de novos desafios para os modelos gerais de julgamento e tomada de decisão. Por último, são discutidas, nesta dissertação, as possíveis consequências e impacto destes

resultados para o estudo de outros mecanismos heurísticos e abordagens teóricas, como por exemplo, a teoria dos níveis de construção.



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## Overview

In the mid-seventies Tversky and Kahneman proposed that most human judgments and decisions rely on a set of simplifying heuristic mechanisms. The goal of their research program was to clarify the cognitive processes underlying these heuristics and specify under what conditions they will be used (e.g., Tversky & Kahneman, 1974). The two most influential heuristics to make predictions and estimate probabilities are representativeness and availability. Whereas representativeness would rely on the judged similarity between the target and prototype of the event; judgments based on the availability heuristic rely on the ease of recall and accessibility of instances. Despite these conceptual differences, representativeness and availability could often explain the same decision outcomes, remaining unclear when people use one or the other heuristic. Unfortunately the initial promise of clarifying the cognitive processes underlying these heuristics was mostly abandoned and representativeness and availability remained overlapped concepts which reduced their predictive or explanatory interest.

The goal of the present dissertation is to empirically disentangle the cognitive processes underlying the representativeness and the availability heuristics and setting conditions for the use one or the other heuristic. This dissertation approaches this question by exploring variables that may be important to understand the mechanisms underlying these heuristics.

In a quick overview of this dissertation, Chapter I will introduce the problematic and the theoretical background that drove the following chapters. It will start by reviewing the initial promise of the heuristic and biases research program (Tversky & Kahneman, 1974) to define the cognitive processes underlying the decision heuristics that rule most human reasoning under uncertainty. Then it will briefly discuss the

chorus of criticism that emphasized how representativeness and availability lack of clear definitions and conditions for its use leads to the overlap between them (e.g., Anderson, 1990; Gigerenzer, 1996). When do people use representativeness and availability remained an unanswered question. It is further claimed that in spite of the notable theoretical efforts that provided important insights to understand the mechanisms underlying these heuristics and what conditions are essential for its use (e.g., Kahneman & Frederick, 2002; Sherman & Corty, 1984), the more recent conceptual differentiation between intuitive and deliberative reasoning (dual process theories) contributed to blur the cognitive differences between different heuristics. Next, three variables that may provide important insights in order to disentangle the cognitive processes underlying these heuristics are discussed and the conditions of its use are identified:

First, representativeness and availability are proposed to differ in their level of abstraction and representativeness is hypothesized to be more abstract than availability. Particularly relevant to understand the effects of different levels of abstraction this chapter will further review the contributions of the construal level theory and use this theory as a framework to propose the test the aforementioned hypothesis.

Second, representativeness and availability are proposed to differ in their cognitive complexity and on their computational speed, and that representativeness should be slower to compute than availability. The test of this hypothesis requires a decision paradigm where both heuristics can be applied but where these heuristics lead to opposite predictions. It is argued that a task where participants have to predict the next outcome of a binary random mechanism after a streak, meet those requirements.

Third the effects of directional motivations on the cognitive processes underlying judgment and decision making are discussed and it is proposed that the information used to compute the representativeness heuristic may change according to

the desired conclusion, and lead to self-serving predictions. It is suggested that this hypothesis could be tested in the context of the hot-hand effect, the tendency to predict the continuation of streaks. In this context, research regarding this effect is reviewed.

The four chapters that follow the theoretical introduction will be presenting empirical papers aim at testing the proposed hypothesis. The final chapter discusses the contributions of these empirical findings for the understanding of the mechanisms that underlie the representativeness and the availability heuristics and for current models of judgment and decision.

## **Chapter I: Introduction**

### **1. Revisiting the “Heuristics and Biases” Research Program**

Making judgments and decisions is the most important thing people do and we do it all the time. From political leaders acting on the social and economic courses of a society to a doctoral student trying to write the very first sentences of his dissertation, predictions, judgments and decisions are made in almost every human activity. It is not surprising then that researchers from many fields became interested in understanding and improving peoples’ reasoning and decisions.

The study of human judgment first focused on a model of rational choice based on the expected utility theory (particularly influential in the field of economics) (e.g., Mongin, 1997; Baron, 1996; 2004). The Expected-utility theory (EUT) deals with decisions under uncertainty, when people choose between options by comparing their expected utility values. That is, the utility of the outcomes weighted according to the probability of that state. Applying such model as norm for human reasoning assumes that people’s everyday judgments and decisions represent the optimal assessment and combination of the probability and of the subjective value (utility) of each possible outcome. This does not only imply the impeccable processing of all variables but also to be attuned to the axioms of formal rationality.

However, researchers soon started collecting evidences that people’s preferences (subjective value) and assessments of likelihood (estimates of probability) did not exactly conform to the normative standards of utility and probability underlying such rational model (e.g., Edwards, 1964; Edwards, Lindman & Savage, 1963; Meehl, 1954; Peterson & Beach, 1967). Why people’s intuitions do not conform to the laws of probability and utility, and what mechanisms does human intuition rely on instead,

became the questions to answer. Despite that many researchers also explored the processes of human preference and subjective valuation (e.g., Baron, 1996; Kahneman & Tversky, 1979), the present dissertation will specifically focus on judgments under uncertainty. More specifically on the cognitive mechanisms underlying people's intuitive probability estimations and predictions.

A very significant step to answer these questions was developed in Herbert Simon's argument that human rationality is bounded by inherent processing (search and computational capacities) limitations, thus making the rational model of choice an unlikely standard for most human judgments. To cope with such limitations, Simon (1957) discussed the use of simplifying but effective heuristics, rendering the use of full-information rational models as high-standard intellectual accomplishments. These so called satisficing heuristics would not guarantee optimal solutions but would make practical the achievement of many tasks that would otherwise fall beyond human cognition capacity (Simon, 1983).

Recognizing that human judgments are constraint by limited processing capacities, Kahneman and Tversky believed that the use of these heuristic processes was not exceptional to problems of excessive complexity or with overload of information. It was rather the process of normal intuitive responses to even the simplest questions about likelihood, frequency, and prediction. Also, the heuristic processes underlying intuitive reasoning were not only simpler than rational models advocate, but also qualitatively different. In principle, these heuristics are distinguished from normative reasoning processes by specific patterns of outcomes that deviate systematically from normative standards derived from probability theory and expected utility theory. However, the heuristics are sensible estimation procedures that represent the structure of the task environment and often rely on sophisticated cognitive processes (e.g., features

matching, memory retrieval). Consequently, these heuristics will perform well in many contexts and can thus be granted high ecological validity. In fact, the discussion of these reasoning heuristics induced some authors to challenge the concept of rationality as depending only on the internal criteria and congruence with normative theories, because measures of rationality should also depend on the structure of the environment (e.g., Gigerenzer, 2008; Simon, 1990). Regardless these different perspectives on the extent with which normative models are more or less adequate judgment standards, all current research approaches converge on giving cognitive heuristics a crucial role in the explanation human reasoning and judgment.

The influential and prolific “heuristic and biases” research program first proposed by Tversky and Kahneman (1974), has as one of its core ideas the notion that people, when confronted with a difficult question, answer an easier (heuristic) one instead, often without awareness of such question substitution. More recently, Kahneman and Frederick (2002, 2005) have made the argument that; whenever the aspect of the judgmental object that one intends to judge (the *target attribute*) (for instance the probability of an outcome) is less readily assessed than a related property that yields a plausible answer (the *heuristic attribute*) (for instance, how easy it is to think of instances of that outcome), individuals may unwittingly substitute the intended probability judgment by the simpler assessment, a process called *attribute substitution* (Kahneman & Frederick, 2002).

Tversky and Kahneman initially described three general heuristics that were based on simple computations and should underlie many intuitive judgments under uncertainty – availability, representativeness, and anchoring and adjustment. Despite its high ecological validity, each of these heuristics was supposed to be unmistakably

associated with systematic and characteristic set of biases (departures from the normative rational theory) that served as hallmarks of the underlying heuristics.

The representativeness heuristic was defined in terms of a similarity assessment between the target instance and a category in memory, and judgments would then be based on the extent to which the target matches or represents the attributes central to the subjective category (Kahneman & Tversky, 1972). To illustrate the use of representativeness, Kahneman and Tversky (1972) asked participants to judge the professional activity of a certain person described with features of a stereotypical engineer but drawn from a pool of 70 lawyers and 30 engineers. Participants typically ignored the base-rates and judged the professional activity based on how representative of an engineer and a lawyer the target is, estimating higher probabilities of being an engineer than a lawyer. In another example, when judging whether “Linda”, a person described as a stereotypical feminist, was more likely to be a professional bank teller or to be a bank teller and a feminist, participants violate the conjunction rule. According to this rule, the probability of two events occurring in "conjunction" (being a bank teller and a feminist) is necessarily smaller or equal to the probability of either one occurring alone (being a bank teller only). However, participants judged Linda as more likely to be a bank teller and feminist than simply a bank teller because Linda was similar to the representation of a feminist.

The availability heuristic, on the other hand, was defined in terms of the mental sampling of specific exemplars, whereby the judged likelihood of an event depends on the ease of retrieval or the accessibility of these specific instances (Tversky & Kahneman, 1973). For instance, in one study participants saw a list with half men’s names and half women’s names. However, men’s (vs. women’s) names on that list were of famous persons. When participants were asked to judge whether there were more

men or women on the list, they overestimated the number of men (or women), because the famous names were more accessible and easy to remember than non-famous names (Tversky & Kahneman, 1973). For another example of the direct effect of accessibility, exposing subjects to subliminally presented words containing the letter t increased frequency estimations of words beginning with “t” (Gabrielcik & Fazio, 1984).

Finally, the anchoring and adjustment heuristic refers to the assimilation of a standard of comparison (the anchor) on subsequent judgments that are (insufficiently) adjusted afterwards (Tversky & Kahneman, 1974, for overviews of more recent accounts see Epley, 2004; Mussweiler, Englich & Strack, 2004). To give a couple of illustrations, Tversky and Kahneman (1974) spin a wheel of fortune device that would randomly generate a number for instance, 65. They then asked participants whether the percentage of African countries in the United Nations was above or below that anchor number, and what value would actually be that percentage. They found that the median estimated of subjects who saw the wheel showing the number 65 was 45%; the median estimated of subjects who saw the number 10 was 25%. In another study, participants were asked whether Gandhi died before or after the age of 9 or, alternatively, before or after the age of 140; and then participants were asked to estimate the actual age of death of Gandhi. Even though all participants new these anchor values did not represent valid responses (non-plausible), participants who were presented with the low anchor of “9 years” thought that Gandhi died at a younger age than those who were presented with the high anchor age of 140 years (e.g., Strack & Mussweiler, 1997). In sum, when people are under uncertainty estimates are guided by non-relevant information (random or non-plausible) and people seem unable to effectively discount its effects.

The heuristics and biases research program has focused primarily on representativeness and availability because these heuristics have a broader scope of

application than the anchoring and adjustment heuristic. Representativeness and availability provide two general, versatile and largely automatic mechanisms that serve as possible answers to many different questions regarding judgement and estimation of probabilities or predictions about the future (e.g., Gilovich, Griffin, & Kahneman, 2002; Kahneman & Frederick, 2002; Kahneman, Slovic, & Tversky, 1982).

Indeed, Hertwig, Pachur and Kursenauer (2005) found that people's choices and estimates of absolute risk frequencies were nicely accounted by computational models based on the availability heuristic (availability by recall) and based on a process akin to representativeness (regressed frequency). Thus, when asked to evaluate the relative frequency of cocaine use in Hollywood actors, one may assess how easy it is to retrieve examples of celebrity drug-users – the availability heuristic piggybacks on highly efficient memory retrieval processes. When evaluating the likelihood that a given comic actor is a cocaine user, one may assess the similarity between that actor and the prototypical cocaine user (the representativeness heuristic piggybacks on automatic pattern-matching processes) (Gilovich, Griffin & Kahneman, 2002). In sum, the heuristic and biases research proposes that representativeness and availability are important and general mechanisms to make judgments and decisions under uncertainty.

Despite the distinct definitions of representativeness and availability, some authors noticed that these early definitions (e.g., Tversky & Kahneman, 1974) were lacking precise process models able to clarify the antecedent conditions that elicit them and how they relate with each other (e.g., Gigerenzer, 1996; Einhorn & Hogarth, 1981; Jungermann, 1983; Shanteau, 1989; Wallsten, 1983). Moreover, not only were these heuristics essentially described by the biases they were supposed to explain, as it was often the case that the same biases could be explained by different heuristics, making it hard to disentangle different heuristic processes (e.g., Anderson, 1990; Schwartz &

Griffin, 1986; Gigerenzer, 1996). That is, assessing the subjective probability or likelihood of an outcome can potentially be answered by relying on representativeness or availability heuristics, and eventually achieve the same decision outcome.

Consider, for instance, that one is asked whether there are more deaths caused by rattlesnake bites or bee stings. To answer this question, one may rely on memory accessibility of instances of deaths caused by rattlesnake bites or bee stings, thus rendering a judgment by availability. Alternatively, one's response may be based on which of these animals' representations is more representative of (i.e., more similar to) a dangerous animal, that is a judgment by representativeness. Assuming that snakes are perceived to be more similar to the representation of a dangerous animal than bees, and to the extent that deaths by snakebites may be more cognitively accessible events than deaths by bee stings, both heuristics would predict the same answer. This example, offered by Anderson (1990), clearly illustrates the potential overlap between these two decision processes. Even though representativeness and the availability heuristics are assumed to rely on different processes the conditions for the use these heuristics are not clear. Therefore, it is hard to identify which heuristic is going to underlie the judgment behavior at any given moment although both heuristics can, a posteriori, be used to explain the same judgment (Gigerenzer, 1991, 1996).

It is thus important to clarify the main heuristic mechanisms people rely on when they judge probabilities or make predictions under uncertainty, illuminating the conditions that promote or trigger the use of representativeness and availability heuristics, and how these heuristics are related (Anderson, 1990; Kahneman & Frederick, 2002; Sherman & Corty, 1984).

Curiously enough most research on heuristics and biases abandoned the initial promise of clarifying the cognitive processes underlying each heuristic and defining the conditions where each would dominate judgments with a few remarkable exceptions.

Some theories of intuition proposed specific cognitive mechanisms underlying judgments and decisions. These mechanisms focused on complex learning and retrieval processes that include storage of multiple exemplars in memory, matching of situations or objects to exemplars or prototypes, and retrieval from multiple-trace memory (e.g., Dougherty, Getty, & Ogden 1999; Fiedler, 2000, 2008; Klein, 1993; Mitchell & Beach, 1990; Thomas, Dougherty, Sprenger, & Harbison, 2008; Unkelbach, Fiedler, & Freytag, 2007). Particularly interesting for the discussion regarding the representativeness and the availability heuristic is the Minerva-DM model (Dougherty, et al., 1999). This computational model is able to simulate most effects associated to the representativeness and the availability heuristics. This model assumes that judgments and decisions are made by probing memory using a judgment question that is compared to the events stored in memory as separate traces. The signal resulting from comparing the probe to memory is proportional to the judged frequency or probability of that probe. The Minerva-DM thus proposes the same fundamental cognitive process to underlie representativeness and availability. However, it says little regarding when one or the other heuristic will be used, as it simply specifies that availability judgments may rely on this simple process due to biased memory encoding (e.g., extra-experiential traces or “overlearning”), whereas representativeness judgments require a conditional probability matching.

Other research on intuition and judgment and decision processes took a different direction that obscured the questions regarding the processes underlying different heuristics, by focusing on discussing the differences between intuition and reflective

reasoning (e.g., Stanovich & West, 2002; Evans & Stanovich, 2013; Kahneman, 2011). This line of research partitioned cognitive processes into two main families – traditionally referred to as the intuitive, heuristic, System 1 or Type 1 processing, versus slower analytical processes, referred to as the deliberative, rational, rule-based, System 2 or Type 2 – and is generally treated under the label of dual-process theories (Chaiken & Trope, 1999; Epstein, 1994; Evans and Over, 1996; Evans & Stanovich, 2013; Hammond, 1996; Kahneman, 2011; Sloman, 1996, 2002; Stanovich & West, 2002). Dual-process theories are diverse, but all distinguish cognitive operations that are quick and associative from others that are slow and governed by rules (Gilbert, 1999). In other words, most of these models assume that intuitive responses are quick and largely automatic heuristic-based processes and that, reflective, slow and controlled processes monitor the quality of the intuitive outputs and may endorse, correct, or override them.

The study of judgment and decision making then focused on understanding these two systems and on what conditions prevent or facilitate intuitive judgment errors from being detected and corrected by the reflective reasoning processes (Kahneman & Tversky, 1982). The contribution of the two systems in determining stated judgments was found to depend on both task features and individual characteristics, including, for instance, the time available for deliberation (Finucane, Alhakami, Slovic, & Johnson et al., 2000), mood (Bless et al., 1996; Isen, Nygren, & Ashby, 1988), intelligence (Stanovich & West, 2002), cognitive impulsiveness (Frederick, 2004), and exposure to statistical thinking (Agnoli, 1991; Agnoli & Krantz, 1989; Nisbett, Krantz, Jepson, & Kunda et al., 1983). The discussion focused on these two qualitatively different systems, its characteristics and dynamics (e.g., Evans & Stanovich, 2013; Kruglansky & Gigerenzer, 2011) has then diverted attention from the initial promise of clarifying the

cognitive processes underlying the different heuristics, and defining the cognitive, motivational and contextual conditions for its use.

The goal of the present dissertation is to help clarifying what cognitive, contextual and motivational conditions lead people to base their judgments on the similarity with categorical representations of past events or patterns (representativeness); or, alternatively, to rely their judgments directly on the most accessible instances of the event, such as the most recent or salient outcomes, to infer higher probabilities (availability).

## **2. When Availability, when Representativeness?**

Representativeness and availability heuristics were described as conceptually vague constructs when it comes to identify when and under what conditions is each heuristic most likely to be used (Sherman & Corty, 1984). The process of attribute substitution occurs when a relatively inaccessible target attribute is assessed by mapping a relatively accessible and related heuristic attribute onto the target scale (Tversky & Kahneman, 1983). Therefore, whether or not representativeness or availability will be used might depend on whether one heuristic attribute or the other is accessible at any given point in time (Kahneman & Frederick, 2002; Sherman & Corty, 1984).

Accessibility in this context refers to the ease (or effort) with which particular mental contents come to mind (see, e.g., Higgins, 1996; Tulving & Pearlstone, 1966). Accessibility of attributes is determined together by the characteristics of the cognitive processes that produce it and by the characteristics of the stimuli and events that evoke it, and it may refer to different aspects and elements of a situation, different objects in a scene, or different attributes of an object (Kahneman & Frederick, 2002).

The characteristics of the stimuli and event are important because the mere accessibility of one attribute may not guaranty its use. The applicability of the accessible information to the target has been shown to influence whether the most accessible information will be applied to the target or not (e.g., Higgins & Brendl, 1995). For instance, unambiguous stimuli have fewer applicable concepts than ambiguous vague stimuli (e.g., Higgins & Brendl, 1995). In the same way even if one heuristic attribute is highly accessible it may not be applicable to the target decision problem. The Heuristic and Biases research program, aimed precisely at providing such unambiguous problems, where only one specific heuristic could be applied. However, part of the initial criticism to this research program, considered these and other decision problems as “ambiguous” in the sense that various heuristics could be applied.

Some single-process models of judgment and decision making, suggest that different heuristic processes can be selected for any given decision task and propose that the selection of a decision mechanism, an heuristics or any other more complex decision rule will depend on memory accessibility, effort and motivational variables, as well as the perceived applicability and ecological validity of these heuristics to the task (e.g., Kruglansky & Gigerenzer, 2011). The importance of task properties in the activation of more or less complex decision processes is also emphasized on the cognitive continuum model proposed by Hammond (1988).

In any case, whether one heuristic attribute is accessible or not for the decision, is a crucial condition for its future use. Moreover, the accessibility of the heuristic attributes is likely increased by the task itself, which should naturally make these accessible heuristic attributes highly applicable to the problems that triggered them. Thus, the characteristics of the task have the potential to activate the use of one heuristic or another. To illustrate, in one study Tversky and Kahneman (1973, Study 7) suggested

that different presentations of the same formal problem, could either make an availability judgment or a representativeness judgment more accessible. The task asked participants to evaluate a binomial distribution with  $5/6$  X's and  $1/6$  O's. In one version of the problem, participants saw a diagram with  $5/6$  X's and  $1/6$  O's distributed by 6 rows and 6 columns. In essence they had to estimate whether there were more paths of 6 items on the diagram that contained 6 X's and no O's or 5 X's and 1 O. This display emphasizes each individual instance used to make a path. Therefore, because there are so many X's when compared to O's, it seems easier to construct paths with all X's. Therefore, based on the availability participants erroneously judged that there are more paths of 6 X's and no O's than paths of 5 X's and one O. In other version of formally the same problem, the proportions of X's and O's in the population were made very salient. Participants were told that 6 players participated in a card game using a deck with  $5/6$  cards marked with X and  $1/6$  cards marked with O. Participants had to judge whether it was more likely these 6 players would receive 6 cards marked with an X and no O's; or to receive 5 cards marked with an X and 1 card marked with a O. Presumably, based on the representativeness heuristic, participants were able to correctly judge that it was more likely to draw  $5/6$  X's and 1 O than 6 X's. The authors argued that in this version of the problem, outcomes were likely to have been judge by the degree to which they were representative or matched the deck's proportions, than by the availability of individual instances.

In this case, the same formal problem presented with a different content elicited different decision strategies suggesting the use of availability in the first version, when individual instances were made salient, and the use of representativeness in the second version, when the population proportions were made salient (Sherman & Corty, 1984; Tversky & Kahneman, 1973; Wallsten, 1980). This was indeed a promising work that

emphasizes how some contextual and framing variables may change judgment outcomes. However, it does not specify or clarify what cognitive processes are underneath these judgments, and why would one heuristic be more likely to be used in one decision context than the other. Therefore, in order to clarify the conditions that render one heuristic attribute more accessible and thus favor the use of representativeness or availability, it is crucial to understand the specific cognitive processes underlying each of these heuristics, and how they interact with specific contextual and motivational variables.

In the following sections I will follow up on previous conceptual work and propose that availability and representativeness heuristics underlie different cognitive processes and that these cognitive differences may be used to think of conditions where one or the other heuristic will prevail. Specifically, I will first argue that these two heuristics underlie different cognitive levels of abstraction. Then I will propose that representativeness and availability also differ regarding its computational complexity and that one heuristic may be faster to compute than the other. Finally, to further understand the mechanisms underlying reasoning heuristics, I speculate that these heuristics may also be sensitive to motivated reasoning.

### **3. Levels of abstraction and the Construal Level Theory**

Notably some theoretical work attempted to clarify the processes underlying each heuristic, thus shedding some light on the conditions that will affect reliance on each of these processes. One particularly important difference between these two heuristics was initially highlighted by Sherman and Corty (1984) and refers to the assumption that each heuristic is based on different information regarding its level of

abstraction. Sherman and Corty (1984) suggested that the difference between representativeness and availability parallels the conceptual distinction between prototype (e.g., Posner & Keele, 1968) and exemplar (e.g., Medin & Schaffer, 1978) models of category learning. According to prototype models, categorization is based on comparisons with an abstraction of the central tendency of the category, whereas exemplar models propose that categorization is based on specific exemplars. This comparison is to emphasize that representativeness heuristic relies on abstract representations, such as the stereotype of a lawyer, a bank teller, or a coin, to which the target is compared; whereas availability relies on how easy is the sampling of specific exemplars from memory, such as individual names from a list, words starting with the letter “t”, or airplane crashes.

The main issue would then be whether knowledge underlying judgment under uncertainty is a general abstraction built up from accumulated previous experiences – representativeness – or a function of more specific instances – availability. Therefore, whether or not representativeness or availability will be used might depend on how the information is encoded and on which aspects of the information are more or less accessible at any given point in time, abstract categorical information or specific exemplar information (Kahneman & Frederick, 2002; Sherman & Corty, 1984). In other words, the role of the two heuristics in response to a decision task might depend on a “contest” of accessibility between specific instances and categorical information (Kahneman & Frederick, 2002).

The level of abstraction to which one approaches a decision problem or the level of abstraction of the context or decision problem itself may then have an important impact on the processes underlying judgments and decisions. One particularly productive and important framework that has explored the role of abstraction in many

different contexts of human behavior and decision making is the Construal Level Theory (CLT) (e.g., Trope & Liberman, 2010).

Research across numerous disciplines has sought to understand the antecedents and consequences of mental abstraction, that is, the process of constructing a mental representation that focuses on the essential features of an object while neglecting the details. Abstraction is thought to play a fundamental role in many basic psychological processes, such as categorization, language development, communication, causal inference, or self-control (e.g., Badre & d'Esposito, 2007; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Semin & Fiedler, 1988; see Burgoon, Henderson, & Markman, 2013, for a review). Mental abstraction has also been shown to be a key mechanism for the potentially unique capacity for humans to mental travel – imagining, simulating; planning and predicting the future; and acting at a distance; remembering the past, relate to other people. The construal level theory provides a framework that articulates mental abstraction with psychological distance and the capacity to transcend the (here and now) immediate perception (Liberman & Trope, 2008; Trope & Liberman, 2010).

According to CLT, mental representations vary as a function of the psychological distance of the target, such that, the greater the psychological distance the greater the level of abstraction. Therefore, the same object is represented differently when it is close vs. distant. Psychologically distant objects are thus processed more globally and construed at a higher level of abstraction, consisting of abstract representations, such as schemas and prototypes that are highly decontextualized. In contrast, psychologically close objects are construed locally and consist of concrete and specific and perceptual details that are highly contextualized (e.g., Liberman & Trope, 2008; Trope & Liberman, 2003, 2010). For instance, the activity of “drinking a beer”

can be at one's immediate experience, pouring beer down the throat, but after some distancing hours, it is seen as having a drink with co-workers; and later it may even be seen as strengthening a friendship bounds.

The CLT considers at least four dimensions of psychological distance – time, space, social relations, and hypotheticality (but see Fiedler, 2007; Liberman, Trope, & Wakslak, 2007 for a discussion about further dimensions of distance) that are all associated. Thus, a distant event in one of the dimensions, should also be perceived as more distant on the other dimensions (Bar-Anan, Liberman, Trope, & Algom, 2007; Fiedler, Jung, Wänke, & Alexopoulos, 2012). Differences in construal levels also produce differences in perceived distance (Liberman & Förster, 2009) and can be procedurally primed (Freitas, Gollwitzer, & Trope, 2004; Fujita, Trope, Liberman, & Levin-Sagi, 2006; Hansen & Trope, 2012; Hansen & Wänke, 2010; Wakslak & Trope, 2009). A priming task can trigger subsequent high-level or low-level construal that influence processing of an unrelated target task. For instance, reflecting on why a behavior is done (vs. how) induces abstract (vs. concrete) construal. Importantly, it is not the semantic content of this and other related priming manipulations that influences the level of construal, instead the priming prompts participants to generally construe situations more abstractly or more concretely (see Trope & Liberman, 2010).

The effects of psychological distance and construal level on perception, evaluation, decision making and behavior are various and well-established (for recent overviews, see Burgoon, Henderson, & Markman, 2013; Liberman & Trope, 2008; Trope & Liberman, 2010; Trope Liberman & Wakslak, 2007). Specifically, construing a decision situation at a more abstract or concrete level has been shown to have a great impact on judgment and decision outcomes because high levels of construal favor the use and the weight given to the more abstract features of an event, whereas low levels of

construal increase the weight of concrete or salient features of the event (e.g., Henderson et al., 2006; Ledgerwood et al., 2010; Nussbaum, Trope, & Liberman, 2003; Pronin, Olivola, & Kennedy, 2008; Trope & Liberman, 2010; Wakslak & Trope, 2009; Wakslak et al., 2006). The following two examples illustrate these effects.

According to CLT, an increase in psychological distance puts an emphasis on an object's core and goal relevant features, accordingly, Trope and Liberman (2000) found that, if one wants to buy a radio to listen to music and has a choice between a radio that has good sound but a poor built-in clock and a radio that has poor sound but a good clock, the first option seems better at distant perspective than from close perspective, and the second option becomes more desirable at a close distance than at a distant one (Trope & Liberman, 2000). In a different study, Henderson and colleagues (2006) asked participants to predict the direction of the next segment of a graph depicting a global upward or downward trend ending with an incongruent local deviation. When the prediction pertained to a psychologically distant target, participants predicted more on the basis of the global trend (rather than the local deviation) than when the information in the graphs was said to pertain to a psychologically close target.

Despite the research focus on the effects of psychological distance and construal level in human judgment and decision making, how these changes in the construal affect the use of specific reasoning heuristics did not receive empirical attention. Some studies have, nonetheless, indirectly explored the effects of construal level on general automatic and intuitive processes vs. effortful and systematic processes proposed by dual-process models, although it remains unclear whether high, or low, levels of construal facilitate or reduce reliance on systematic and effortful processes. For instance, research investigating whether high or low levels of construal would affect processing effort and depth failed to find any systematic differences between the effects

of distance on construal and measures of involvement or even accuracy motivation (e.g., P. K. Smith & Trope, 2006; Wakslak et al., 2006). Similarly, Ledgerwood et al. (2008) used the number of thoughts generated about an attitude object as a measure of systematic processing and found that the number of thoughts was unaffected by temporal distance from the attitude object.

There is also mixed evidence, with results supporting that under some conditions high levels of construal increase systematic processing (e.g., Fujita, Eyal, Chaiken, Trope & Liberman, 2008) and self-control (e.g., Fujita, Trope, Liberman & Levi-Sagi, 2006; Fujita & Carnevale, 2012) but that under other conditions, low levels of construal facilitate these systematic and controlled processes (e.g., Fujita, et al., 2008; Schmeichel, Vohs & Duke, 2010). For instance, Fujita and colleagues (2008) tried to address the issue of heuristic processing of persuasive messages by examining sensitivity to argument strength, a commonly used test of heuristic processing (Chaiken, Giner-Sorolla, & Chen, 1996; Petty & Cacioppo, 1984). They presented participants with either strong or weak arguments from a wildlife conservation organization. that either referred to a superordinate category (e.g., orcas in Puget Sound) or subordinate, specific exemplar (e.g., Simon, an orca in Puget Sound) of the attitude object. The results showed that when the arguments referred to a high-level category, attitudes were more sensitive to argument strength when the attitude object was temporally distant than near. However, when the arguments referred to a subordinate exemplar, attitudes were more sensitive to argument strength in the near than in the distal condition.

According to Trope and Liberman (2010) extracting the general meaning and invariant characteristics of objects is not necessarily more or less effortful than scrutinizing the details of those objects. Therefore, CLT does not predict any systematic

effect of the level of construal on the reliance on more automatic and intuitive processes or on more effortful and systematic processes.

As argued before the cognitive specificities of different heuristic mechanisms such as representativeness and availability are blurred by general dual-process accounts. Therefore, to understand the effect of construal level on intuition it is essential to take into account these cognitive specificities and differentiate the kind of information upon which these heuristics depend, either more abstract (prototypical) or more concrete (exemplar-based) information.

### **■ The effects of construal level on heuristic reasoning**

The level of construal may then be one determinant of the reliance on one or the other of these two reasoning heuristics. As high levels of construal involve more abstract representations, we hypothesize that they should facilitate judgments by representativeness. On the other hand if the core of low levels of construal is concrete and detailed features, then low levels of construal should facilitate availability judgments.

Judgments based on the availability heuristic predict that more concrete and vivid events are more likely to occur because this information is easier to recall. According to availability heuristic, several studies have shown that increasing the vividness and salience of certain events increase the judged probability of those events. (e.g., Newell, Mitchell, & Hayes, 2008; Sherman, Cialdini, Schwartzman, & Reynolds, 1985; Slovic, Monahan, & MacGregor, 2000). Previous studies manipulating the level of construal have found that low levels of construal increase the vividness and concreteness of the events, thus yielding similar increases in the perceived likelihood of the events. For instance, in a study manipulating the psychological distance of a risky

event, an “every day” framing of the event made risks more proximal and concrete than an “every year” framing, which resulted in increased risk perception (Chandran & Menon, 2004). In the same vein, prior to a probability estimation task, priming the level of construal (by generating either superordinate categories or subordinate exemplars of 40 objects) led participants primed with a concrete mindset to judge the target events as more likely to occur than participants primed with an abstract mindset (Wakslak & Trope, 2009). These studies thus suggest that reliance on the availability heuristic to estimate frequencies and judge probabilities is increased when the level of construal is low and judgments are construed upon more concrete instances.

On the other hand the effect of the level of construal on tasks where representativeness is assumed to be at play should be facilitated when the problem is construed at a higher and more abstract level. Representativeness heuristic implies a two-step process of substitution. First, the substitution of an event by an abstract prototype; second, the substitution of the target attribute of probability by a judgment of similarity between the target and the prototypical representation (Kahneman & Frederick, 2002, 2005). Illustrations of the representativeness heuristic, such as the lawyers and engineers base-rate problem (Kahneman & Tversky, 1973) or the Linda conjunction problem (Tversky & Kahneman, 1983), commonly show how responses congruent with a judgment of similarity between the target and an abstract prototype are preferred over a response based on a sampling rule in the case of base-rate problems, or a conjunction rule, in the case of conjunction problems. Conditions increasing the accessibility of abstract representations, such as high construal mind-sets, should facilitate the substitution of an event by an abstract prototype and increase the perceived similarity between the target and that prototype. High levels of construal thus impose superordinate categories (Fujita, Trope, Liberman, & Levin-Sagi, 2006; Liberman,

Sagristano & Trope, 2002), which are likely to promote representativeness by highlighting the described target as a member of a broader category.

Moreover, research on construal level has also shown that high levels of construal facilitate the perception of similarities between stimuli (Förster, 2009; Friedman, Fishbach, Förster, & Werth, 2003; McCrea, Wieber, & Myers, 2012). In fact, judgments based on stereotypes are favored by more abstract levels of construal (e.g., McCrea, et al., 2012; Milkman, Akinola, & Chugh, 2012), precisely because this mindset will focus perceivers' attention on similarities between a target and a salient social category (e.g., McCrea, et al., 2012). In the case of problems designed to elicit the representativeness heuristic, an abstract mindset will lead to perceive the target as more similar, or representative, of the critical category. For instance in the Linda problem, at a high-level of construal, Linda should be best described as a "feminist". In contrast, under a low construal level, people are more likely to focus on the target's specific and salient features that distinguish it from other similar targets (e.g., Henderson & Wakslak, 2010; Tsai & Thomas, 2011). Such concrete focus would potentially undermine or interfere with judgments by representativeness.

The first empirical work of this dissertation explores the hypothesis that the level of abstraction with which a person approaches the judgment task contributes to the heuristic attribute used in the judgment. In sum, it is proposed that because representativeness and availability heuristics conceptually suppose different cognitive processes, where the former is more abstract than the later; the level of abstraction underlying the decision process should be an important condition to predict whether one will decide based on representativeness or availability. The proposed differences in the level of abstraction of these heuristics should provide an important first step to clarify what cognitive mechanisms underlie the two heuristics. In the following section, I will

discuss and propose differences in the cognitive complexity that should have an impact on the computational speed of representativeness and availability.

#### **4. Differences in cognitive complexity among heuristics**

Heuristics are supposed to reduce the effort associated with decision processes (Shah & Oppenheimer, 2008). As such, dual process models, have defined heuristics as largely automatic processes that are fast to compute and require little cognitive effort, in opposition to deliberate reasoning processes (e.g., Edwards, 2007; Kahneman, & Frederick, 2002; Sloman, 1996; Stanovich & West, 1997). It follows that while deliberate processes are likely to be disrupted by cognitive load or time constraints, heuristic reasoning is expected to be unaffected by such variables (see Evans, 2008; Glöckner & Witteman, 2010; Kahneman, 2003 for overviews). As discussed before, the focus on dual process models may obscure the differentiation of heuristic processes stemming from intuition. Therefore, even though these intuitive heuristics are largely automatic, and assumed to be fast and easy to compute, *automaticity* is not an all-or-none process in terms of its defining features (see Bargh, 1994; Wegner & Bargh, 1998). It is assumed that the properties ascribed to automatic (and often intuitive) processes, such as modularity, speed, autonomy, resource-free and non-conscious processing, might not all co-occur (e.g., Bargh, 1992; Kahneman & Treisman, 1984; Logan & Cowan, 1984). Many of these features may actually be mere incidental correlates (Stanovich, 1990). This is to say that heuristics as intuitive processes may be largely or relatively automatic. If different heuristic mechanisms, such as representativeness and availability, postulate different cognitive structures and processes, it is likely that they also operate under different cognitive demands.

Predictions by representativeness (Kahneman & Tversky 1973; Tversky & Kahneman, 1983) invoked two assumptions. First the substitution of a representative exemplar for a categorical representation (e.g., a dangerous animal, or bank tellers) and second that the probability that the target belongs to a category (e.g., are bees dangerous animals?) is judged by the degree to which the individual resembles (is *representative* of) the category stereotype. . Availability heuristic, on the other hand, is assumed to underlie a single substitution of the heuristic attribute of accessibility of specific instances for the target attribute of probability (Kahneman & Frederick, 2002; 2005).

Representativeness and availability may imply a different processing of the same information. Yet, when abstract representations (or prototypes) and specific instances are accessible, it is possible to compute both representativeness and availability. In such conditions, a consequence of defining representativeness as a two stage process of attribute substitution is that the computation of a judgment by representativeness should take longer than computing a judgment by availability, that rely directly on instances' accessibility. In fact, reliance on the representativeness heuristic seems to be constrained by time-pressure manipulations (Villejoubert, 2009). For instance, the conjunction fallacy (Tversky and Kahneman, 1973) was found to be reduced when the time to process and respond to the conjunction problem was constrained (Villejoubert, 2009). This result is consistent with the idea that heuristic responses requiring a two stage attribute substitution process (representativeness) need more processing time to be fully computed than relying directly on the accessibility of instances, a single attribute substitution (availability). However, it seems that when such two stage process is completed (substitution for a prototype and computing a judgment of similarity), the representativeness-based response should take precedence over availability-based responses. Research on the availability heuristic shows that, if

participants are aware of an alternative explanation for an item's accessibility, the effect of accessibility disappears (Kubovy, 1977; Oppenheimer, 2004; Schwarz, 1998; Schwarz et al., 1991; Waenke, Schwarz, & Bless, 1995). For example, when judging the frequency of certain letters in a text, participants overestimate the frequency of their own name's initials (because our own name initials are chronically accessible), but underestimate their frequency if they had previously used their initials in an unrelated task (Oppenheimer, 2004, Study 3).

These results suggest that, even though specific instances are accessible, people do not necessarily rely on the availability heuristic (e.g., Gabrielcik & Fazio, 1984; Oppenheimer, 2004). They may discount the direct effect of accessibility, and ease of recall, and rely on other judgment processes, such as representativeness (e.g., Kubovy, 1977). That is, although disregarding the heuristic attribute of availability in the aforementioned examples may involve more complex processing; this does not mean judgments will be dominated by sophisticated analytical reasoning. It seems rather more likely that people will rely on other heuristic attributes instead; such as representativeness.

In sum, it is proposed that, conceptually, the cognitive processes underlying representativeness heuristic, a two-step attribute substitution process, should take longer to compute than computing the availability heuristic, a single attribute substitution).

This assumption imposes another condition for the use of representativeness and availability heuristics besides the accessibility of the attributes underlying these heuristics. If these heuristics have different efficiency, representativeness heuristic should be more sensitive to time constraints (e.g., Villejoubert, 2009), than judgments by availability. This is particularly important when both heuristics suit the decision task, because the computation of the availability heuristic should be completed before

representativeness. The processing time conditions to generate a judgment may thus provide an important variable to conceptually and empirically disentangle representativeness from availability, by setting the conditions for the use of one or the other mechanism. However, the ideal setting to test whether one heuristic is computed before the other should directly pit availability against representativeness. Therefore it will have to be a decision context amenable to both heuristics, but where the responses suggested by the two heuristics are in opposition.

One potentially interesting paradigm in order to fulfil these requirements is the context of predictions random binary events after a sequence. The following section will argue why such paradigm may be an interesting one to tackle the hypothesized differences in the computational speed of availability and representativeness.

### **■ What's next paradigm: pitting one heuristic against the other**

One classical demonstration of the representativeness heuristic is the effect known as the gambler's fallacy (e.g., Tversky & Kahneman, 1971). The gambler's fallacy refers to the belief that the probability of the end of a streak (i.e., a sequence of repetitions of an outcome) increases with the size of the streak. Take for instance predictions about coin tosses. The sample information from previous tosses should have no effect on the prediction of any single independent toss (but see Hahn & Warren, 2009 for a discussion). However, the data from other tosses seems to be used as a basis of judgment for individual tosses, and for instance, after a streak of three "heads", the next outcome of a coin toss is expected to be a "tail" and end the streak. This common finding has been attributed to the use of representativeness heuristic (for an overview and different accounts see, Oskarson, Van Boven, McClelland, & Hastie, 2009).

According to representativeness heuristic, the coin toss event is substituted by a prototypical sequence of binary random events. People's representations of binary random events expect sequences with very few streaks and approximately 50% heads and 50% tails even in small samples (e.g., Bar-Hillel & Wagenaar, 1991; Lopes & Oden, 1987; Wagenaar, 1972). The probability of the next outcome is substituted by a judgment based on the similarity between that prototypical sequence of binary random outcomes and the observed streak of "heads". Because streaks are considered non-representative rare events of random mechanisms, people tend to expect that the following outcome will bring the overall level of heads and tails closer to the expected value of 50% every time the observed sequence deviates from that representation, thus leading to predictions of the end of the streak (Kahneman & Tversky, 1972; Tversky & Kahneman, 1971). The experimental paradigms where the "gambler's fallacy" is observed typically ask participants to predict the next outcome after a sequence of repeated outcomes generated by a binary random mechanism. This paradigm potentially satisfies the methodological needs to pit representativeness against availability in the same decision task.

As argued, representativeness heuristic predicts that in a coin toss scenario a streak is expected to end, because people represent binary random events with many alternations, few streaks, and expect to observe these properties with the following outcomes. Therefore, after three "heads" in a row, participants typically predict the next outcome will be a "tail". However, as a streak unfolds, the outcome that is being repeatedly observed becomes cognitively more accessible. For instance, observing a streak of three "heads" should increase the accessibility of that outcome. If one was to predict the next outcome following that streak of "heads" based on the availability heuristic, she should guess "heads", and the streak would be expected to continue.

This suggests that, in a coin toss scenario, after a streak, the prediction of the next outcome will depend on whether the judgment is based on representativeness or availability. Representativeness based judgments would predict the end of the streak, whereas a response based on availability would predict the continuation of the streak. Note however, that even if availability heuristic is computed before representativeness, in such decision paradigm, people's intuitive response typically predicts the end of the streak. Therefore responses do not seem to rely directly on the most available answer, for example, guessing "heads" after a streak of heads.

Two factors may contribute for the apparent predominance of judgments based on representativeness rather than availability in this paradigm. First, the standard use of this paradigm may lead people to discount the effects of availability (e.g., Kubovy, 1977; Oppenheimer, 2004). Even though the repetition of an outcome, "heads", can make the response "heads" more accessible, in this paradigm participants are clearly aware that the outcome is being repeated. The repeated presentation of the outcome "heads" may provide participants with a potential cause for the increased accessibility of "heads". Therefore, rather than using the accessibility of "heads" as a heuristic to predict one more repetition of that outcome, people may discount the effect of availability and rely on a different decision heuristic.

Indeed, previous research has shown that if there is a plausible cause for instances accessibility, people will discount the effects of availability in their judgments (e.g., Kubovy, 1977; Oppenheimer, 2004). When that is the case, it is likely that, if representativeness judgments are completed, they would take precedence over availability. On the other hand, if the accessibility of instances is subtly increased people seem to use the availability heuristic (Bar-Hillel, Peer, & Aquisti, 2014; Gabrieli & Fazio, 1984; Kubovy, 1977; Oppenheimer, 2004). For instance, Michael

Kubovy (1977) asked participants to generate the first digit that spontaneously comes to mind. When participants were subtly primed with the digit 1, by being asked to report the “first one-digit number that comes to mind” they were more likely to report “1” than when the digit 1 was mentioned by the experimenter as an example of a response (“Write down the first number that comes to mind...like 1”). In this study, explicitly mentioning the digit 1 provided participants with a potential cause for the increased accessibility of that digit, thus leading participants to disregard that digit as a spontaneous response.

In some tasks about coin tosses there is also evidence suggestive of the use of availability heuristic when participants are not aware of potential causes for the increased accessibility. In coin toss tasks there is a linguistic convention describing the two possible outcomes as “heads or tails”. Thus, when participants are asked to generate sequences of coin tosses, their first mental toss tends to be “heads” rather than “tails”. This effect can be easily reversed if the task is presented as “tails or heads” (Bar-Hillel et al., 2014). This *reachability bias* (Bar-Hillel et al., 2014) suggests that when participants are mentally simulating the first outcome of a sequence, they are not aware of the effects of the accessibility of the first outcome mentioned in the task label (“heads or tails” or “tails or heads”). Additionally, in the first toss it is not clear what response would representativeness heuristic predict, because there may not be a prototypical first toss for random events. Thus the mental simulation of the first toss does not seem to be a task that suits the representativeness heuristic, and participants seem to rely on the availability heuristic. This mental simulation task contrasts with tasks where participants have to predict the following outcome of a coin toss after the presentation of a streak. In this case it is likely that the observed streak provides a plausible cause for

instances accessibility. The availability would then be discounted and the decision maker would rely on another heuristic, such as representativeness.

Moreover, in the standard use of this “what’s next?” paradigm, participants are in optimal conditions to compute the representativeness heuristic. That is, participants have the time and the attentional resources to retrieve a prototypical sequence of coin tosses, and then judge the similarity between that prototype and the observed streak. Thus, after a streak of “heads”, the availability of “heads” can be replaced by the more “representative” option, “tails”. This may be an important variable if representativeness heuristic is more complex and takes longer to compute than the availability heuristic. In fact, early studies on probability learning found that when these optimal conditions are not met due to increased stress or fatigue, the alternation response pattern, expected by representativeness heuristic, is reduced and predictions of streak’s continuation become more likely (e.g., Feldman, 1959; Lindman & Edwards, 1961; Derks, 1962; Friedman, et al., 1963). For instance, Edwards (1961) showed that in a 1000-trial probability learning task predictions of alternation tend to disappear in later trials. Moreover, this reduction in alternation responses (and increase in continuation responses) was stronger with the increase of the streak length.

These findings are congruent with the hypothesis that predictions of streaks’ alternation based on the representativeness heuristic, may take more time to be computed than the prediction of streak’s continuation, which may be a result of the availability heuristic. Presumably, the absence of cognitive resources or motivation may have reverted judgments by representativeness into a somewhat more quickly computed response by availability, and predict the next outcome according to the most easily accessible response.

Developmental studies on probability learning also suggest that predicting the end of a streak, may be the result of more sophisticated processes than positive recency, (e.g., Derks & Paclisanu, 1967; Jones & Liverant, 1960; Atkinson, Sommer, & Sterman, 1960; Craig & Myers, 1963; Ross & Levy, 1958). Young children between 3 and 4 years old predict very simply, expecting the continuation of the last observed outcome. Moreover, children until 8 years old progressively predict the repetition of the last outcome as the streak length increases until the observation of five repetitions in a row (e.g., Derks & Paclisanu, 1967). Yet, Cohen and Hansel (1958) show that older children, of 10 years old, have a strong tendency to predict alternations, as they seem to represent binary events as exhibiting symmetry or an alternation pattern.. As different and more complex representations of binary events are acquired with aging, adolescents show a reduction in the tendency to alternate in some contexts (Cohen & Hansel, 1955).

In sum, participants tend to predict the end of the streak because this paradigm typically favors the discounting of the availability on the one hand, and the computation of representativeness on the other. That is, participants are perfectly aware of the repeated presentation of one of the outcomes, the streak, and this may provide a reason why this outcome is particularly accessible, thus leading to discount the effects of this availability in the subsequent prediction. Moreover, participants also have the time and attention to process the information and compute a judgment by representativeness.

In such conditions, representativeness judgments should take precedence over availability, and people will predict the end of a streak. If, however, after observing a coin toss streak, participants cannot discount the increased accessibility that results from the repeated presentation of an outcome, and if they cannot compute a judgment by representativeness, predictions should be based on the availability heuristic and lead to the prediction of streak's continuation.

The hypothesized difference in the cognitive efficiency between these two heuristic mechanisms can then be tested using this prediction task about random binary outcomes. If representativeness is more sensitive to time constraints than the availability heuristic, then predictions of the next outcome after a streak under time-pressure conditions should lead to an increase in responses based on the availability heuristic. That is, time pressure conditions should lead to more predictions of streak's continuation than conditions where predictions are not made under time-pressure. This task provides the ideal paradigm to contrast the computational speed of representativeness and availability and thus test whether representativeness heuristic takes longer to compute than availability allowing an important step to clarify the differences between these two heuristics and setting the conditions for the use of one or the other. Two empirical works that will be presented later on, will test some of the aforementioned hypotheses using the "what's next" paradigm. Braga, Ferreira and Sherman (2013) and Braga, Ferreira, Sherman and Mata (invited for resubmission) give the first steps to test the hypothesis that judgments by availability (predicting a streak's continuation) are computed more quickly than judgments by representativeness (predicting a streak's end) and because of that the processing-time constraints should affect the use of representativeness but not of availability.

## **5. Motivated Reasoning**

So far it was proposed that the level of abstraction to which one construes a decision task, and the time available to compute a decision heuristic may have an impact on the heuristic mechanisms underlying the decision. Based on the view of motivation as a cognition (Kruglanski, et al., 2002) that affects other cognitive

processes (e.g., Kunda, 1990), the following section argues that motivational variables may also impact the computation of these decision heuristics and help us to understand its underlying mechanisms.

The study of how motivation affects judgements and decision has a long story in psychological sciences (e.g. Bem, 1972; Bruner & Goodman, 1947; Festinger, 1957). Motivated reasoning refers to the influence that motives, desires, preferences, or goals to achieve certain outcomes or to use certain strategies can have on judgment and reasoning (Kunda, 1990; Molden & Higgins, 2005). For instance, the desire to see ourselves in a positive way or the desire to be accurate in any given task were perhaps the most studied human motives known to influence our reasoning. The former refers to directional motivation, that is, the motivation to reach specific desired conclusions that allow, for instance, a positive image of themselves or their groups as having success or other positive attribute (e.g., Dunning, 1999; Kunda, 1990, 1999; Molden & Higgins, 2005). The later represent a non-directional motivation, that is, the motivation to seek certain attributes or qualities in their reasoning no matter what the ultimate specific conclusion (e.g., Fiske & Neuberg, 1990; Thompson, Roman, Moskowitz, Chaiken, & Bargh, 1994).

Motivational variables have been shown to have a strong impact in almost any psychological process, even at very early perceptual stages of processing (e.g., Balcells & Dunning, 2006). Particularly important for the present dissertation, how motivational variables may affect the use of reasoning heuristics has received insights from both the study of non-directional and directional motives. These two motives may affect judgments and decisions by two different processes. Non-directional motives lead to the use of beliefs and strategies that are considered the most appropriate, whereas

directional motives lead to the use of those that are considered most likely to yield the desired conclusion (e.g., Kunda, 1990).

In what regards non-direction motivation, some studies failed to reduce decision biases associated to the use of heuristics by adding incentives for accurate responses to participants (Fischhoff, 1977; Kahneman & Tversky, 1972a; Lord, Lepper, & Preston, 1984; Tversky & Kahneman, 1973), perhaps because people responding to such problems did not have access to alternative response strategies. Yet, many others studies have shown that people do put more effort and rely on more sophisticated reasoning processes, for instance, processes that integrate more information, when they are motivated to be accurate in their reasoning (e.g., Kruglanski & Thompson, 1999a, 1999b; Petty & Cacioppo, 1986).

Directional motivation has perhaps received more attention from researchers of motivation. Many decision outcomes have positive or negative consequences, making some outcomes more desirable than others, thus the motivation to achieve a certain desirable conclusion seems to impact many cognitive processes and judgment and decision strategies, potentially affecting the use of specific heuristic mechanisms.

Particularly important for the present argument, the motivation to observe certain outcome leads people to search for decision rules and to consider, otherwise unattended, information that will support the desired conclusion. That is, directional goals seem to bias the selection of procedural knowledge structures (Kunda, 1990). For instance, participants motivated to find a specific outcome have been shown to be able to make judgments of covariation following more sophisticated rules (e.g., a Delta-p contingency rule) rather than relying on more simple decision rules (e.g., Mata, Ferreira & Sherman, 2013; Munro & Stansbury, 2009). In other studies, people have been shown to consider base-rate information (Ditto et al., 1998; Ginosar & Trope, 1987), sample

properties (Doosje, Spears, & Koomen, 1995; Sanitioso & Kunda, 1991), or hypothesis-disconfirming instances (Dawson, Gilovich, & Regan, 2002), in their judgments, which typically do not occur when directional motivation is absent.

These effects of directional goals on reasoning have been interpreted as reflecting the impact of motivation on more basic cognitive processes such as biasing memory search (Kunda, 1990). Accordingly, some studies suggest that motivation has an effect on memory recall and knowledge activation, leading to the selective activation of concepts and recall of events that support desirable views. For instance, studies by Sanitioso, Kunda, and Fong (1990) asked participants to read fictitious articles supporting that either introverts or extroverts are more prone to academic and professional success. When participants believed that introversion was linked to success they were more likely and faster to recall instances where they performed introverted behaviors than extroverted behaviors. When participants were lead to believe that extroversion was linked to success the reverse pattern of recall was found.

These effects of directional outcome motivation on selective recall of information, can also lead to selective reconstruction of previous memories (e.g., McDonald & Hirt, 1997) and to influence more implicit processes of knowledge activation and accessibility (e.g., Sinclair & Kunda, 1999). For an example of the effect of directional goals in implicit knowledge activation, Sinclair and Kunda (1999) considered that one way people have of perpetuating a positive view of themselves is to venerating others who provide positive feedback while vilifying those who provide negative feedback. To illustrate, in one of their studies individuals either received positive or negative feedback from a person who was a member of both a stereotypical positive (doctor) and a stereotypical negative (African American) social category. Those who received positive feedback were faster than baseline to identify doctor related

words and slower than baseline to identify African American-related words on a lexical-decision task (suggesting that they were suppressing the negative social category of the person giving the positive feedback). The reverse pattern was found for those who had received negative feedback (as they were suppressing the positive category of the person giving the feedback) (Sinclair & Kunda, 1999).

This research supports the notion that directional motivation does indeed increase the accessibility of information congruent with the desired conclusion. It is thus suggestive that the effect of directional motivation on reasoning may be mediated by such changes in memory accessibility for knowledge structures that will support the desired conclusion. Kruglanski in his Goal Systems Theory (Kruglanski et al., 2002) further suggests that goals are in fact associated to means of achieving those goals and that the activation of a certain goal will increase the accessibility of knowledge structures that are means to achieve that goal (e.g., Shah & Kruglanski, 2002). Therefore, we argue that the goal to observe a certain outcome increases the accessibility of the knowledge and information needed to compute the desired conclusion.

These conclusions are particularly interesting for the understanding of heuristic decision mechanisms. As argued before, the computation of different heuristics depend on the accessibility of the different heuristic attributes (Kahneman & Frederick, 2002). If one is motivated to observe a certain outcome or achieve some specific conclusion, this directional goal may affect these cognitive processes by increasing the accessibility of the information computed by the different heuristics, in order to achieve the desired conclusion. Motivation may not only increase the effort and sophistication of reasoning in order to justify a desired outcome (e.g., Mata et al., 2013) but also have a simpler effect on reasoning by increasing the accessibility of the heuristic attributes that better

serve the decision maker. Specifically, we hypothesize that judgments based on representativeness or availability heuristics may then depend on directional goals. For instance, when making a prediction between two options based on the availability heuristic, instances accessibility for each option are accessed. The outcome with the most easily accessible memory instances will be judged as more likely. The desirability of these outcomes may however make instances congruent with the most desirable outcome more accessible than instances supporting the alternative, and less desirable, outcome (e.g., Santos et al., 1990). This will guide the prediction that the desired outcome is more likely to occur.

The same effects may be expected when judgments and predictions rely on the representativeness heuristic. When deciding between two possible outcomes of an event, the option that is most similar of the prototypical representation of the event being accessed will be judged as more likely to occur. If one of the outcomes is more desirable than the other, then it is possible that the representation of the event will be influenced by the motivation to observe the desirable outcome. Directional motivation may affect how the event is represented in a self-serving way. Specifically, the event will be represented in such a way that it will be considered more similar to the desirable outcome than to the other possible alternatives. If the prototypical event used to compute representativeness is similar to the desired outcome, a judgment based on the representativeness will then lead to judge that the desired outcome is a likely outcome of that event. As described before, Sinclair and Kunda (1999) found that when processing a person that is a member of two categories, the category membership that better serves the observer's goals becomes more accessible. Therefore, the representation of the event retrieved and used to compute representativeness heuristic should render the desired outcome as the most representative.

The fourth empirical paper of this dissertation explores the potential effect of directional motivation on the representativeness heuristic in the context of the hot-hand effect. The representativeness heuristic has been used to explain some apparently contradictory results, such as the gambler's fallacy (tendency to predict the end of a streak) and the hot hand effect (tendency to predict the continuation of a streak). In these cases, coming to the conclusion that the streak will end or continue, based on the representativeness heuristic, will depend on the representation of the target event used to compute the heuristic. Therefore, it is likely that directional goals will affect the knowledge used to compute the representativeness heuristic and the decision outcomes. In this context, the following section briefly reviews previous research on the hot hand effect.

### **■ The Hot-hand effect**

People have tendency to perceive patterns in random events (for a review, see Nickerson, 2004) and to inadvertently introduce patterns by too-frequently alternating among potential outcomes when asked to spontaneously generate random sequences (e.g., Wagenaar, 1972). The representation of events and processes as possessing such systematic patterns will then have consequences when one has to make predictions about those events. For instance, as explored in the previous chapter, the prediction of a coin toss's outcome after a streak is an alternation of the streak because coin tosses are represented as leading to many alternations and few streaks. However, other processes or events are perceived and represented as if local streaks are likely to continue, even when such patterns do not exist.

In the original paper demonstrating the hot hand fallacy, Gilovich, Vallone and Tversky (1985; see also Tversky & Gilovich, 1989a, 1989b) showed the absence of a

“hot-hand” pattern in basketball performance, a domain in which such perceptions of streak shooting pattern were strongly ingrained, which made their conclusions persuasive. In a set of statistical analyses, they showed that streaks were no more prevalent than one would expect assuming that shots were truly independent of each other. Some researchers have argued that these statistical analyses were flawed (e.g., Sun, 2004; Wardrop, 1995) and that statistics cannot account for the complexity of the game (e.g., Hooke, 1989; Larkey, Smith, & Kadane, 1989). However, other researchers have shown that people endorse the hot hand fallacy in the domain of roulette, where each event is objectively independent of the previous event (e.g., Croson & Sundali, 2005; Wagenaar, 1988). The central point here is that people represent events as possessing systematic patterns even in random data, which is crucial to our understanding of the cognitive mechanisms that underpin human probabilistic reasoning.

Thus, when people witness an unexpected streak (e.g., several heads from a series of coin tosses, or numerous scoring shots in basketball), the interpretation of this streak depends on their prior assumptions (e.g., Moldoveanu & Langer, 2002). Whereas people expect coin tosses to be random, they are willing to entertain the possibility that streaky performance in a domain like basketball. A consequence of these different representations is that when people compute the representativeness heuristic to predict the following outcome after a streak; a new coin toss is expected to end the streak, but a new basketball shoot is likely to be a continuation of the streak

Researchers have then tried to understand when events are represented as having many alternations and few streaks, and when events are represented as streaky processes. A particularly important factor is whether the mechanism generating the sequence is perceived as a random process or not (Ayton & Fischer, 2004; Burns &

Corpus, 2004; Tyszka, Zielonka, Dacey, & Sawicki, 2008). For instance, people tend to predict that streaks generated by a non-random agent, such as a basketball player shooting, will continue whereas those generated by a random agent, such as coins being tossed, will revert (Ayton & Fischer, 2004; Burns & Corpus, 2004). In fact, simply describing an ostensibly random agent in animate, goal-driven terms increases people's tendency to report that a streak will continue compared to when the random agent is described as an object (Morris, Sheldon, Ames, & Young, 2007).

However, whereas some researchers suggest that the observation of human skilled performance is the critical factor that elicits predictions of streak continuance (Ayton & Fischer, 2004); others suggest that predictions of streaks are contingent on the perceived randomness of the performance, regardless of whether it is human or not (Tyszka, et al., 2008). Therefore, and because intentional agents are perceived to be skilfully guiding their action and therefore controlling the outcome (Malle & Knobe, 1997), Caruso, Waytz and Epley (2010) suggested that the perceived intentionality of the streak's agent may be the one unifying determinant of people's beliefs. Caruso et al., (2010) manipulated the agent's intentions while controlling for its humanness and randomness, and found that intentional agents are expected to continue their streaks. They also found that, because people naturally assess intentionality to different degrees when attempting to identify and explain systematic patterns in complex behavior (Rosset, 2008), those who were more likely to see agents as intentional judged the observed streaks as more likely to continue. The perceived intentionality of the agent thus seems to be an essential variable when representing the event as a process that tends to alternate or to continue its streaks (Caruso et al., 2010). When people make predictions about the next outcome of an event after a sequence, they may rely on the representativeness heuristic, thus comparing the observed sequence to these

representations of the event. If the event is perceived as intentional, then it is represented as a process where streaks will tend to continue. If the event is perceived as non-intentional, then it is represented as a process where streaks will tend to end. Judgments and predictions relying on the representativeness heuristic will then be based on these representations of the event, and lead to predict streak's continuation in the former case or its alternation in the later.

The fourth empirical paper presented in this dissertation argues that, when computing the representativeness heuristic to predict the next outcome after a streak, directional motivation should affect the representation of the event used to compute representativeness. As a consequence of comparing such self-serving representations of the event to the observed sequence, people should predict that the sequence will unfold with the desired outcome. This will illustrate how motives can affect the cognitive processes underlying decision heuristics and help us to clarify these mechanisms. The following section will summarize the goal of this dissertation and introduce the empirical chapters that will test some of the aforementioned hypothesis.

## **6. Clarifying the cognitive processes underlying representativeness and availability heuristics**

One of the goals of the “heuristic and biases” research program was to clarify the cognitive processes underlying judgment and decision heuristics and specify what conditions lead people to rely on each specific heuristic (e.g., Tversky & Kahneman, 1974). The representativeness and the availability heuristics are good examples of how these decision heuristics remained commonly used to explain many judgment and decision making processes involving frequency and probability estimation, even though

it is often unclear which of these heuristics was actually used for the judgment or decision. Unfortunately, and despite distinct general definitions, the cognitive processes underlying these heuristics were not conceptually nor empirically clarified. The overlap between these heuristics remained as research focused on the distinction between general intuitive processes dominated by heuristics, and deliberative processes where analytical and rule-based reasoning applies (e.g., Chaiken & Trope, 1999).

Whether a certain judgment or decision is going to rely on the representativeness, or on the availability heuristic, remains to a large extent an unanswered question. The goal of the present dissertation is to provide a better understanding of the cognitive processes underlying these heuristics and shed some light on the conditions affecting the use of these heuristics.

A crucial aspect regarding heuristic reasoning and the selection of these heuristics is that people rely on heuristics in order to substitute a target attribute that is hard to access. In those cases of uncertainty people rely on an easily accessible heuristic attribute. The accessibility of the heuristic attributes is thus an essential aspect to compute a heuristic. Whether one heuristic attribute is more or less accessible for the decision may determine its use (Kahneman & Frederick, 2002; 2005; Sherman & Corty, 1984). Therefore, any conditions increasing the accessibility of a heuristic attribute should favor its subsequent use.

Based on the conceptual definitions of the representativeness heuristic and the availability heuristic, this dissertation proposes to empirically explore the processes underlying these heuristics. Representativeness was defined as a two-step process where a prototype of the event has first to be accessed, and is then used as a standard to which the target is compared and judged as more or less representative. The availability heuristic on the other hand relies on a single process where judgments can rely directly

on instances accessibility or on the ease with which concrete specific occurrences are brought to mind. Two differentiating aspects pop-out from these definitions:

- a) First, the representativeness heuristic depends on somewhat more abstract information than the availability heuristic (Kahneman, & Frederick, 2002; Sherman & Corty, 1984). If representativeness computes the similarity between the target and a prototype of the event, this category's prototype should be more abstract knowledge than the specific instances used to compute availability.
- b) Second, the representativeness heuristic is conceptually more complex and should take longer to compute than the availability. If representativeness implies a two step-process (retrieving of a category's prototype, and compute a judgment of similarity) whereas availability depends on a single process of accessing instances accessibility then, when both heuristics can be applied, representativeness should take longer to be computed.

These two conceptual differences between representativeness and availability suggest ways of empirically disentangle these two heuristics and setting conditions for their use. First, whether a decision problem is construed at more or less abstract level may facilitate the use of, respectively representativeness or availability; Second, when both heuristics can be applied to the decision problem, the time available to compute the decision heuristic may constraint the computation of representativeness but not of the availability heuristic.

Additionally, motivated reasoning should also affect the use of decision heuristics and thus increase our understanding of its underlying mechanisms. In fact, an important variable that has been shown to impact the accessibility of different knowledge structures is the participant's motivation (e.g., Kunda, 1990). Specifically

directional goals have been shown to increase memory accessibility for information that will lead to the desired conclusion (e.g., Sanitioso et al., 1990; Sinclair & Kunda, 1999). Because the computation of these heuristics depends on the accessibility of these attributes, directional motivation is likely to affect judgments and decision outcomes and the information upon which the heuristic will rely. Thus, in the case of representativeness heuristic, the motivation to observe a certain outcome, should lead to use a prototype of the target's event that will render the desired conclusion as the most representative of the event.

The following four empirical chapters propose to test these hypotheses. The first empirical chapter tests whether representativeness heuristic is conceptually more abstract than the availability heuristic. Making use of the construal level theory (Trope & Liberman, 2010) as framework to manipulate the level of abstraction, it is tested whether decision problems where representativeness and availability are expected to be used, are sensitive to such manipulations. High levels of abstraction should increase reliance on decisions based on the representativeness heuristic, whereas low levels of abstraction should facilitate reliance on the availability heuristic. The second and third empirical papers tested whether judgments based on the representativeness heuristic are more complex and thus take longer to compute than the availability heuristic, when both heuristics can be applied to a decision task. In order to test this hypothesis, these empirical chapters suggest that tasks where participants have to predict the next outcome generated by a binary random mechanism (Oskarson et al., 2009) provide a paradigm where both heuristics can be applied but where representativeness and availability predict opposite outcomes. While the representativeness predicts the end of streaks (the gambler's fallacy), availability should predict streaks continuation as this is the most accessible outcome. Time pressure manipulations are expected to constraint

the computation of the representativeness heuristic but not of the availability. The fourth empirical chapter explores the role of directional motivation on the use of the representativeness heuristic. When people predict the outcome of sport outcome people tend to predict the continuation of streaks because these events are perceived as generated by intentional agents that tend to control the outcomes of the events (Caruso et al., 2010). This work will test whether the motivation to observe the continuation or the end of a streak will impact how people represent the event and what beliefs become more accessible in order to support the desired conclusion that will consequently render the desired outcome as the most representative and likely to occur.

**Chapter II: The effects of construal level on heuristic reasoning: The case of representativeness and availability – Braga, J., Ferreira, M. B., & Sherman, S. J. (2014).**

**1. Introduction**

Research on Construal Level Theory (CLT) has shown that psychological distance affects the extent to which people think about an event, person, or idea in more concrete or abstract terms (e.g., Trope & Liberman, 2010). These changes in the level of construal have been shown to affect judgments and decisions in several domains, although its effect on the use of classical judgment heuristics such as representativeness (judgments based on the similarity between a target and its abstract representation) and availability (judgments based on the accessibility of specific instances) (Tversky & Kahneman, 1974) remains unclear (Trope & Liberman, 2010). In the present article, we propose that high levels of construal may facilitate the use of representativeness whereas low construal levels should favor the use of the availability heuristic. Such findings would contribute to a better understanding of the cognitive processes underlying these heuristics and would help define the conditions under which these heuristics are more likely to be used.

**■ Construal Level Theory**

According to CLT, the content of high construal levels consists of abstract mental representations (such as schemas and prototypes) and underlies a more global processing of information. In contrast, low-level construals consist of concrete and specific details, focusing on local processing of perceptual elements (e.g., Liberman & Trope, 2008; Trope & Liberman, 2003, 2010). The level of construal has been shown to

increase with psychological distance (temporal, spatial, social) (for a review see Trope & Liberman, 2010), but it can also be procedurally primed (Freitas, Gollwitzer, & Trope, 2004; Fujita, Trope, Liberman, & Levin-Sagi, 2006; Hansen & Trope, 2012; Hansen & Wänke, 2010; Wakslak & Trope, 2009). A priming task can trigger subsequent high-level or low-level construals that influence processing of an unrelated target task. For instance, reflecting on why a behavior is done (vs. how) induces abstract (vs. concrete) construals. These and other related priming manipulations prompt participants to construe situations more abstractly or more concretely (see Trope & Liberman, 2010)<sup>1</sup>.

Construing a decision situation at a more abstract or concrete level has been shown to impact judgment and decision outcomes (e.g., Henderson, Fujita, Trope, & Liberman, 2006; Ledgerwood, Wakslak, & Wang, 2010; Nussbaum, Trope, & Liberman, 2003; Pronin, Olivola, & Kennedy, 2008; Trope & Liberman, 2010; Wakslak & Trope, 2009; Wakslak, Trope, Liberman, & Alony, 2006), although it remains unclear how these changes in the level of construal affect heuristic processing.

Research exploring the effect of the level of construal on judgment and decision making suggests that high levels of construal favor the use of and the weight given to the more abstract variables of an event, whereas low levels of construal lead to more weight given to concrete or salient variables. For instance, when participants had to predict the direction of the next segment of a graph depicting an upward or downward trend, they predicted more on the basis of the global trend rather than the local deviation when the information in the graphs was said to pertain to a spatially distant group (high level construal condition) rather than when it was said to pertain to a spatially near

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<sup>1</sup> Importantly, it is not the semantic content of the priming tasks that influences the level of construal. Instead, the general tendency to construe information abstractly versus concretely is procedurally primed by the tasks.

group (low level construal condition) (Henderson, Fujita, Trope, & Liberman, 2006). In another study, Ledgerwood et al., (2010) asked participants to choose between two products. One product was favored by aggregate information, such as average reviews of the product. The other product was favored by individualized information, such as a particular opinion. High construal conditions (vs. low construal), induced by a temporal distance manipulation, increased the relative weight placed on aggregate information compared to the weight placed on individualized information.

How might the level of construal affect heuristic processing? We suggest that this will depend on which heuristics are called for in a given judgment situation and on the kind of information upon which these heuristics depend, either more abstract or more exemplar-based information.

## ■ Heuristics and biases

The two most studied heuristics (e.g., Gilovich, Griffin, & Kahneman, 2002; Kahneman, Slovic, & Tversky, 1982) have been the representativeness and the availability heuristic. Although it has sometimes been difficult to empirically tease apart these heuristics and determine under what conditions representativeness and availability are used (e.g., Anderson, 1990; Gigerenzer, 1991), the conceptual natures of the two heuristics refer to very different cognitive processes. Judgments by representativeness rely on the extent to which a target matches a categorical abstract representation (Kahneman & Tversky, 1972), whereas judgments by availability rely on the accessibility or ease with which specific instances are brought to mind (Tversky & Kahneman, 1973).

The effect of the level of construal on heuristic reasoning may depend on which heuristic is at play, and manipulating the level of construal may be one determinant of

the use of one or the other of these two reasoning heuristics. Specifically, as high levels of construal involve abstract representations, they should facilitate the use of the representativeness heuristic. Low levels of construal, which focus on concrete exemplars, should facilitate the use of the availability heuristic.

According to the availability heuristic, more concrete and vivid events tend to be perceived as more likely to occur (e.g., Newell, Mitchell, & Hayes, 2008; Sherman, Cialdini, Schwartzman, & Reynolds, 1985; Slovic, Monahan, & MacGregor, 2000). Previous studies manipulating the level of construal found that low levels of construal increase the use of availability heuristic. For instance, in a study manipulating the psychological distance of a risky event, an “every day” framing of the event made risks more proximal and concrete than an “every year” framing, which resulted in increased risk perception (Chandran & Menon, 2004). In the same vein, priming the level of construal (by generating either superordinate categories or subordinate exemplars of 40 objects) prior to a probability estimation task led participants primed with a concrete mindset to judge the target events as more likely to occur than participants primed with an abstract mindset (Wakslak & Trope, 2009). Although these results suggest that low levels of construal favor the use of the availability heuristic when this heuristic suits the task, the effect of construal levels on tasks where representativeness is assumed to be at play remains unexplored.

According to the representativeness heuristic, whenever a target event is recognized as part of an abstract representation, judgments may rely on the similarity between that target and its parent population. Illustrations of the representativeness heuristic, such as the lawyers and engineers base-rate problem (Kahneman & Tversky, 1973) or the Linda conjunction problem (Tversky & Kahneman, 1983), commonly show how responses congruent with a judgment of similarity between the target and an

abstract representation, such as a stereotype, are preferred over a response based on a sampling rule in the case of base-rate problems or a conjunction rule in the case of conjunction problems.

Research on construal level has shown that high levels of construal facilitate the perception of similarities between stimuli (Förster, 2009; Friedman, et al., 2003; McCrea, et al., 2012). Moreover, judgments based on stereotypes are favored by more abstract levels of construal (e.g., McCrea, et al., 2012; Milkman, et al., 2012), precisely because this mindset will focus perceivers' attention on similarities between a target and a salient social category (e.g., McCrea, et al., 2012).

Moreover, another fundamental distinction between high-level and low-level construal is a focus on core features, leading people to think in more abstract, categorical terms. Thus, Linda (in the Linda problem), at a high-level of construal, is best described as a "feminist". It is the imposition of these superordinate categories that likely promotes representativeness by highlighting the described target as a member of a broader category (Fujita, Trope, Liberman, & Levin-Sagi, 2006; Liberman, Sagristano & Trope, 2002). In contrast, under a low construal level, people are more likely to focus on the target's specific and salient features that distinguish it from other similar targets (e.g., Henderson & Wakslak, 2010; Tsai & Thomas, 2011). Such a focus potentially undermines or interferes with judgments by representativeness.

In sum, if representativeness accounts for base-rate neglect and the conjunction fallacy in these paradigms, then high construal levels, compared to low construal conditions, should facilitate the use of the representativeness heuristic, increasing neglect of the conjunction rule in the Linda problem and of the base rates in the lawyers and engineers problem. In contrast, low construal level conditions should decrease the use of representativeness by decreasing the level of abstraction with which participants

represent the personality descriptions of the actors featured in the problems (e.g., Linda) and consequently the degree of similarity between these descriptions and the corresponding parent population or category (e.g., feminist).

In three studies, we tested this hypothesis. In Study 1, we manipulated the psychological distance in the Linda conjunction problem, and we expected participants to be more likely to commit the conjunction fallacy when the problem was framed in a spatially distant scenario than in a near one. In Study 2, we primed the level of construal by inducing an abstract or concrete mindset before having participants complete the base-rate problem of lawyers and engineers, and we expected more base-rate neglect when an abstract mindset was primed. Finally, in Study 3 we tested the differential effect of the level of construal on the representativeness and availability heuristics by priming either a concrete or abstract mindset and presenting participants with inferential problems that evoked either the representativeness or the availability heuristic. Here, abstract mindsets should facilitate the use of representativeness whereas concrete mindsets should increase decisions based on availability.

## **2. Study 1**

### **Method**

#### **Participants**

Forty-eight students, 72% women, mean age of 19.58 ( $SD = 10.04$ ), from the University of Lisbon received one credit for their participation in the study. In this study and in the following studies here reported, we stopped running participants at the end of the semester.

## **Procedure**

Participants were randomly assigned to either the high or low psychological distance condition. They first saw two conjunction problems, both framed either in a distant or near spatial scenario, in order to manipulate psychological distance.

As in the classic Linda conjunction problem (Tversky and Kahneman, 1983), participants were presented with a stereotypic description of a target (stereotype of a feminist for the first problem and of a singer for the second problem) and were then asked whether that target was more likely to belong to a group that did not resemble the target's stereotype (e.g., a bank teller) or to belong both to a non-stereotypic group and to a stereotypic group (e.g., a bank teller and a feminist).

In the near spatial scenario condition, the characters of both problems were described as living in Lisbon, Portugal. In the distant spatial scenario condition, the characters of both problems were described as living in cities of distant countries (Praha, Czech Republic and Salzburg, Austria). The remaining features of the characters were exactly the same for both conditions.

## **Design**

The design was a 2 distance (near vs. distant) x 2 conjunction problems (feminist vs. singer), with repeated measures on the second factor. The dependent variable was the proportion of responses selecting the two-feature event as the most likely option (i.e., the conjunction fallacy). No other conditions were included, and no additional measures were collected.

## Results and Discussion

A 2 distance (near/distant) x 2 problem (feminist/singer) ANOVA revealed, as predicted, a main effect of distance  $F(1, 46) = 8.75, p = .005, \eta^2 = .17$ , showing that participants in the distant condition were more likely to commit the conjunction fallacy ( $M = .83, SD = .06$ ) than participants in the near condition ( $M = .56, SD = .06$ ). No other effects were found. This suggests that the increase in the psychological distance increased the use of the embedded stereotype to make the decision. Representativeness predicts that the conjunction fallacy occurs when the description of the target resembles the representation of a certain group, thus leading to the neglect of the conjunction rule. At the same time, the observed reduced conjunction fallacy when psychological distance is low suggests that this manipulation made it more difficult to retrieve an abstract representation and consequently decreased its judged similarity with the target<sup>2</sup>.

In sum, the increase in the conjunction fallacy when abstract (vs. concrete) representations of the problems are primed via psychological distance provides evidence consistent with the classic understanding of the processes involved in representativeness.

### 3. Study 2

Study 1 suggests that high psychological distance led to greater use of the representativeness heuristic than low psychological distance. This is likely the result of an increased use of abstract representations for a distant rather than a near framing of the conjunction problem. Study 2 proposes to extend this finding to the base-rate

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<sup>2</sup> Note, however, that this result suggests a reduction in the use of representativeness heuristic but it does not clarify whether participants in the low level of construal are more likely to use the conjunction rule or if they are simply more likely to randomly respond to the problems.

problem of the lawyer and engineer. In this problem, Kahneman and Tversky (1973) asked participants to judge the profession of a target whose description, randomly drawn from a pool of 30 engineers and 70 lawyers, was slightly stereotypic of an engineer. Participants neglected the base rates and judged the target as more likely to be an engineer when the description resembled the corresponding stereotype. According to the representativeness heuristic, they did so because the requested probability judgment was replaced by a judgment of similarity between the target's description and the abstract representations or stereotypes of an engineer and of a lawyer (Kahneman & Frederick, 2002). If this is so, then high construal, when compared to low construal, mindsets should increase the reliance on judgments by representativeness.

## ■ Method

### Participants

119 students, 37% women, mean age of 19.66 ( $SD = 1.62$ ), from Indiana University received one credit for their participation in the study.

### Procedure

Participants were randomly assigned to either the high or low construal level priming conditions. In the high construal level priming task, participants had to imagine themselves in the future and list five activities they would pursue in one year. In the low construal level priming task, participants had to list and describe five activities from their to-do list for the next day (e.g., Förster, Friedman, & Liberman, 2004).

After the priming manipulation, participants responded to three base-rate problems. Each problem presented a randomly drawn description of a target from a sample of 100 people consisting of two groups, one with 90 and the other with 10 members. The target's description was stereotypic of the smaller group, stereotypic of

the larger group, or not stereotypic of either group. All problems were based on De Neys and Glumicic (2008) (see supplemental material for details)

## **Design**

The conditions consisted of 2 construal level priming (high/low) X 3 target stereotype (the larger group, the smaller group, or neither group), with repeated measures on the second factor. The dependent variable was the proportion of responses selecting the group with the higher base rate (i.e., 90%). No other conditions were included, and no additional measures were collected.

## **Results and Discussion**

First we tested whether there were differences in the frequencies of responses congruent with the base rates (i.e., responses judging the target as a member of the large group) within the 3 description conditions. McNemar's pairwise comparisons revealed that participants were less likely to judge the target as a member of the large group when the description was stereotypical of the small group, (19% of responses congruent with the base rates) than when the target's description was both stereotypical of the large group (97% of responses congruent with the base-rates  $\chi^2(1, 119) = 93.00, p < .001; \phi = .003$ ) or stereotypical of neither group (82% of responses congruent with the base-rates,  $\chi^2(1, 119) = 75.00, p < .001; \phi = .025$ ). Neutral descriptions also led to fewer judgments of the target as a member of the larger group than did congruent descriptions ( $\chi^2(1, 119) = 13.50, p < .001; \phi = .0028$ ).

To test for the interaction between target's description and the level of construal, we contrasted, for high and low levels of construal, the frequency of participants

selecting the small group for the incongruent description (but not for the congruent and/or neutral descriptions) against the frequency of participants who selected the larger group for the incongruent description (but not for the congruent and/or neutral descriptions)<sup>3</sup>. As predicted, Fisher's exact test revealed a significant interaction between description conditions and the level of construal ( $\theta = 1.25$ ;  $p = .039$ ;  $\phi = .208$ ). No differences were found between the congruent and neutral descriptions for high and low levels of construal ( $\theta = 1.09$ ;  $p = .854$ ;  $\phi = .0002$ ). Thus, as expected, for incongruent descriptions (when compared to congruent and neutral descriptions), selecting the small group is more likely for high than low construal level.

Logistic regressions for each problem description with the level of construal as a single predictor provided further support to our specific hypothesis. Construal level priming had an effect on participants' judgments when the description was incongruent with the base rates ( $B = -1.04$ ;  $SE = .50$ , Wald  $\chi^2(1, 119) = 4.34$ ,  $p = .037$ ), such that high construal level priming led to lower judgments of the target as a member of the larger group (12%) (i.e., more base-rate neglect) than low construal level priming (27%). When the description was stereotypic of neither group, there were no differences in extent to which participants followed the base rates and judged the target as a member of the larger group between high construal (77%) and low construal level conditions (86%;  $B = -0.57$ ;  $SE = 0.49$ , Wald  $\chi^2(1, 119) = 1.33$ ,  $p = .250$ ). When the description was stereotypic of the larger group, most participants judged the target as a member of the larger group whether the construal level was high (98%) or low (98%;  $B = -0.69$ ;  $SE = 1.24$ , Wald  $\chi^2(1, 119) = 0.31$ ,  $p = .576$ ).

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<sup>3</sup> The remaining participants, who selected the small or the large group consistently for the three descriptions, were equally distributed among both conditions.

These results support a representativeness account for base-rate neglect in this paradigm. Assessing the perceived similarity between a target and the categorical information was facilitated by an abstract mindset compared to a concrete mindset. In the incongruent problem, the increase in judgments of the target as a member of the smaller group for high construal priming conditions, thus neglecting the base rates, suggests that participants may indeed compute the similarity between the target and a category in memory in order to make their decision. This supports the use of the representativeness heuristic in this task.

Because most participants judged the target as a member of the smaller group when the description was stereotypic of the small group, we may further hypothesize that, if they did so because they relied on representativeness to make their judgment, then responses of those in high construal mindsets may have been facilitated when compared to those in low construal mindsets. We used a reaction times analysis (log transformed) to measure such facilitation. As expected, in the high construal condition, participants' responses that ignored the base rates were significantly faster ( $M = 20901.83\text{ms}$ ,  $SD = 1675.66$ ) than in the low construal condition ( $M = 25191.75$ ,  $SD = 1839.07$ ;  $F(1, 95) = 4.29$ ,  $p = .041$ ,  $\eta^2 = .04$ ). This result further supports the idea that abstract mindsets do indeed facilitate the use of an abstract representation to make the decision, which is in accordance with a representativeness heuristic account for base-rate neglect in the lawyer and engineer problem.

Studies 1 and 2 suggest that the level with which one construes a problem may affect reliance on the representativeness heuristic. Specifically, as representativeness depends on the comparison between a target and an abstract representation, more abstract mindsets or increased psychological distance lead to more responses based on

representativeness, as these conditions presumably facilitate the access and reliance on abstract categorical representations in order to make the decision.

#### **4. Study 3**

Although Studies 1 and 2 suggest that high construal levels increase the use of representativeness, the effect of more abstract versus concrete mindsets should not be the same for all reasoning heuristics. If representativeness involves abstract information whereas availability depends on the accessibility or the ease with which concrete specific instances are brought to mind (Kahneman & Frederick, 2002; Sherman & Corty, 1984), then the level of construal should determine the use of representativeness versus availability in different ways.

Priming an abstract mindset should increase heuristic responses in tasks where the representativeness heuristic can be applied, when compared with the priming of a concrete mindset. However, the priming of a concrete mindset should increase the use of the availability heuristic when the task is suitable for the use of that heuristic, when compared with the priming of an abstract mindset.

In Study 3, we primed participants with either an abstract or concrete mindset and asked them to solve two problems, one suitable for representativeness (the base-rate problem of lawyers and engineers, Kahneman & Tversky, 1973), and the other suitable for availability (the famous names problem, Tversky & Kahneman, 1973).

In previous studies using the famous names problem, participants saw a list of names containing slightly more names of women than men (or the same number). However, men's names on that list belonged to celebrities. When participants were asked to judge whether there were more men or women on the list, they commonly judged there to be more men. This effect has been interpreted as resulting from the

availability heuristic. Because famous names are more salient, men's names are more accessible and more easily brought to mind than women's names, thus leading to the overestimation of men (Tversky & Kahneman, 1973).

We used both the famous names problem and the lawyer and engineer problem in order to test for the effect of the level of construal on the use of both the representativeness and the availability heuristics.

## **Method**

### **Participants**

Sixty nine students, 33% women, mean age of 19.45 ( $SD = 1.15$ ), from Indiana University received one credit for their participation in the study.

### **Procedure**

Participants were randomly assigned to either the abstract mindset priming condition or to the concrete mindset priming condition. Participants were asked to engage in sequential reasoning about why (abstract priming) or how (concrete priming) they would engage in a certain behavior, such as improving and maintaining their physical health (see Freitas, Gollwitzer, & Trope, 2004 for details).

After the priming, participants were presented with the lawyer and engineer base-rate problem using a frequency format (see Gigerenzer & Hoffrage, 1995). Specifically, they were presented with 10 exemplars reflecting the proportion of lawyers and engineers in the sample (90% lawyers and 10% engineers). After seeing the exemplars, participants saw a description of a person randomly drawn from that sample, although the description always portrayed a stereotypic engineer. Participants then selected whether the person in the description was more likely to be a lawyer or an engineer.

After their response, participants' mindset (abstract or concrete) was refreshed with a similar priming task. This time they had to reason about how or why they might improve and maintain their social network.

They were then presented with the "famous names problem". In this problem, participants were told that they would see a list of names. The list of 30 names contained 50% male and 50% female names. Ten of the masculine names were of famous personalities. Two female names were also famous personalities in order to reduce the distinctiveness between the two lists. The non-famous names were selected from the census 2011 list of the 20 most frequent names in the United States. The list of names was presented in a random order, with each name presented in the center of the screen. After seeing the list, participants decided whether there were more men's or women's names on the list<sup>4</sup>.

### **Design**

The design was a 2 construal level priming (high/low) x 2 problems (representativeness/availability) factorial, with repeated measures on the second factor.

The dependent variable was the proportion of responses predicted by the representativeness and availability heuristics. For the lawyer and engineer problem, these are the responses against the base rates (i.e., the description belonged to the small group of engineers); and for the famous names problem, these are the responses selecting the gender with more famous names as the more frequent (i.e., there were more men than women on the list). No other conditions were included, and no additional measures were collected.

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<sup>4</sup> Participants had only two response options in order to facilitate comparison with responses to the base-rate problem, and to force a biased response, since it was not possible to correctly respond that both groups had the same number of names on the list.

## Results and Discussion

To test whether the type of heuristic problem (base rates vs. famous names) interacted with the level of construal priming, we contrasted, for high and low levels of construal, the frequency of participants who gave the heuristic response to the base-rate problem (i.e., judged the target as a member of the small group) but not to the famous name problem, against the frequency of participants who gave a heuristic response to the famous names problem (i.e., overestimated the number of men), but not to the base-rate problem. Fisher's exact test showed a marginal interaction between these variables,  $\theta = 2.20$ ;  $p = .058$ ;  $\phi = .036$ . Moreover, for the base-rate problem, logistic regression showed that participants were marginally more likely to neglect the base rates for the high construal condition (89% of responses neglecting the base rates) than for the low construal condition (71%);  $B = 1.17$ ;  $SE = 0.65$ , Wald  $\chi^2(1, 69) = 3.24$ ,  $p = .072$ . However, for the availability problem, logistic regression analysis revealed that participants were more likely to give a heuristic response, and to judge men as more frequent than women, for the low construal condition (79%) than for the high construal condition (54%);  $B = 1.18$ ;  $SE = 0.54$ , Wald  $\chi^2(1, 69) = 4.70$ ,  $p = .030$ .

These results demonstrate that construal level priming differentially affected the responses to the two problems. A high construal level, as opposed to a low construal level, increased base-rate neglect and reliance on the stereotypic description of the target. These results thus replicate the findings of Study 2, even when the base rates were presented in frequency format, which should facilitate its use (Gigerenzer & Hoffrage, 1995). On the other hand, low construal levels, associated with the use of concrete information, favored the use of the availability heuristic in the famous names problem. In this case, relying directly on the accessibility of instances was more likely for concrete mindsets than for abstract mindsets. As in previous studies (e.g., Chandran

& Menon, 2004; Wakslak & Trope, 2009), where probability and frequency estimations were higher for concrete mindsets, participants in the concrete mindset priming condition were more likely to judge that there were more men than women than were participants in the abstract mindset priming condition. This is in line with the notion that famous names become even more salient under concrete or low construal level mindsets.

Results of Study 3 show that the impact of construal level on the use of judgment heuristics depends on the applicability of the specific heuristic under consideration. In fact, the differential effects of construal level manipulations on the use of representativeness and availability indicate that these heuristics involve different cognitive processes, with judgments by representativeness relying on abstract information and availability judgments relying on the accessibility of specific instances.

## **5. General Discussion**

CLT has shown how differences in psychological distance or approaching a problem with a more abstract or concrete mindset can change the process and outcome of our judgments and decisions. In this paper, we provide some evidence of how changes in the level of construal may affect the use of the two most studied judgment heuristics, representativeness and availability. Our studies provide evidence that inferential problems aimed at eliciting the use of the representativeness heuristic, such as the Linda problem (Study 1) and the lawyer and engineer problem (Studies 2 and 3), lead to more responses congruent with this heuristic (i.e., more conjunction fallacy and more base-rate neglect) when the level of construal is high rather than low. Study 3 further shows, within participants, that not only do high levels of construal lead to more

judgments by representativeness but also that low levels of construal lead to more responses predicted by the availability heuristic (overestimating the frequency of instances of a salient over a non-salient group, in the famous names problem). The differential effects of the level of construal on the use of the representativeness and availability heuristics support the conceptual difference between the cognitive processes underlying these two heuristics.

### **Disentangling availability from representativeness**

Although the conceptual natures of availability and representativeness involve different processes, the same judgments and the same biases have sometimes been explained by both heuristics (e.g., Anderson, 1990; Gigerenzer, 1991). This problem has been used as a criticism of the heuristic approach, and has been especially evident for decision problems involving individuating information such as the lawyer/engineer base-rate problem. Some have considered the base rates in this problem to be rather remote, pallid, and abstract (Gigerenzer, Hell, & Blank, 1988; Nisbett & Borgida, 1975; Nisbett & Ross, 1980) in opposition to the usual depiction of base-rate information as vivid, concrete, and salient (Kahneman & Tversky, 1972), making the availability heuristic a plausible alternative account for base-rate neglect. Thus, it is not clear whether base-rate information should be considered as concrete or as abstract information. From our point of view, base-rate information is neither highly concrete nor highly abstract. Rather, such information falls in between the two extremes on the continuum from concrete to abstract. That is, base rates are simple and specific concrete numbers. Yet they represent general population statistics that are not specific to any single individual.

This ambiguity about the level of concreteness of base rates can help us understand why some previous research has reported that high-level construals promote

greater sensitivity to base rates (thus reducing the bias in judgments; Burgoon, Henderson, & Walker, 2013; Henderson et al., 2006; Ledgerwood et al., 2010). Such results are, of course, in the opposite direction of our results of less sensitivity to base rates with high-level construals. One reason for this seeming inconsistency involves the alternative to using base-rate information in the different studies. In the case of Henderson et al. (2006) and Ledgerwood et al. (2010), the alternative to base rates was a far more concrete possibility. For Henderson et al. (2006), the two possible bases for judgment were global information from outcomes over a long period of time (i.e., base-rate information) versus a very local recent and specific outcome. In such a case, high-level construal would favor the use of base rates, the more abstract information. Similarly, Ledgerwood et al. (2010) pitted population information (i.e., base rates) versus information about one specific person. Again, high-level construal would increase the likelihood of using the more abstract and less concrete information, the base rates.

In our studies, the alternative to base-rate information was the stereotypic description of an individual. In this case, the alternative to the base rate was more abstract, and a judgment of the similarity of the description to the prototypical lawyer (or engineer), the representative heuristic process, would be more likely under a high-level of construal. From our point of view, the results of the aforementioned studies taken together with the results reported here support a representativeness-based account of base-rate neglect. Whichever basis for judgment, the base rates or the alternative (e.g., the target description), is more abstract, the greater weight will be given to that basis under a high construal level.

However, it is also possible that differences in time pressure, accuracy motivation, or level of cognitive fluency could account for the different results found

across the various studies. For example, manipulating the interpretation of fluency has been shown to reverse the effect of construal level on evaluative judgments (Tsai & Thomas, 2011). Future research should investigate the role of these factors in moderating the effects of construal level on the use of judgment heuristics.

In any case, the impact of construal level suggests a way to discriminate between representativeness and availability accounts of base-rate neglect. We suggest that representativeness underlies base-rate neglect. When the base-rate information is more abstract than the alternative, a high level of construal will increase the use of base rates. However, when the base-rate information is less abstract than the alternative, as in our studies, representativeness will lead to less use of the base rates (i.e., more base-rate neglect). Although quite plausible, the assumed mediational role of representativeness was not directly tested. Such a test would also be one interesting avenue for future research. Specifically, the extent to which a profile is stereotypic of an engineer should be perceived as more relevant and receive more weight in conditions of high construal level when compared to low construal level.

### **Construal level theory and reasoning heuristics.**

Previous research has failed to find differences in motivation or accuracy due to changes in the level of construal (e.g., Smith & Trope, 2006; Wakslak et al., 2006) that could affect reliance on heuristic processes. However, our results suggest that, more than having a general effect on the use of heuristics, high and low levels of construal may affect the use of specific heuristics in agreement with the different types of information and cognitive processes upon which these heuristics rely. This also strongly suggests that the cognitive processing grounded in high-level construal is not more or less rational or proscriptively better or worse than cognitive processing grounded in low-level construal. Both construal levels can promote short-cuts in information

processing (along with their corresponding biases). Depending on the particular problem, both high-level and low-level construals can either increase or reduce bias. If the relevant heuristic is representativeness (e.g., the Linda problem), a high level of construal will increase the bias (i.e., greater conjunction fallacy) whereas a low level of construal will decrease the bias (i.e., reduced conjunction fallacy). On the other hand, when the relevant heuristic is availability (e.g., the famous names problem), a high level of construal decreases the bias (i.e., fewer heuristic-based errors in frequency judgments) whereas a low level of construal will increase the bias (i.e., more errors in frequency judgments). These findings nicely complement previous research demonstrating that both high-level and low-level construal can promote systematic or elaborative information processing under the right conditions (see Fujita, Eyal, Chaiken, Trope & Liberman, 2008, Study 3).

The present studies also help to clarify the conditions under which representativeness and availability are used, which is of critical importance in establishing the explanatory value of these heuristics and in addressing previous criticisms (e.g., Anderson, 1990; Gigerenzer, 1991). Our results show that high and low levels of construal increase specific judgment biases stemming from representativeness in the former case and availability in the latter case. Although these effects do not reflect pure measures of the processes underlying representativeness and availability, our findings are congruent with the proposed cognitive differences between representativeness and availability processes, according to which the representativeness heuristic relies on abstract representations whereas availability relies on the accessibility of specific instances. Thus, the present studies provide empirical evidence for the theoretical efforts that previously emphasized these differences between representativeness and availability (e.g., Kahneman & Frederick, 2002; Sherman &

Corty, 1984). Future research should explore measures that would more directly reveal the processes underlying these heuristics, as well as extend these findings to other contexts and heuristic mechanisms (e.g., Gigerenzer & Goldstein, 1996). Moreover, it would be of much interest to understand how progressive changes in the abstract/concrete continuum would help us to understand the relation between availability and representativeness.

## **Chapter III: Disentangling Availability from Representativeness: Gambler's Fallacy under pressure – Braga, J., Ferreira, M. B., & Sherman, S. J. (2013).**

### **1. Introduction**

Research in judgment under uncertainty was transformed in the 70s when Tversky and Kahneman introduced the “heuristics and biases” research program. These authors challenged the use of rational models as explanations for human judgment and suggested that three simplifying heuristics (qualitatively different from normative models) underlie most human judgments under uncertainty (Tversky & Kahneman, 1974). The goal of their early experiments was to associate each heuristic with a set of biases, which should serve as hallmarks of the underlying heuristic. Unfortunately, soon researchers realize that often the same biases could be explained by different heuristics (e.g. Gigerenzer, 1996), which put into question the explanatory value of these heuristics.

This problem is particularly striking in the case of availability and representativeness.

In fact, although the conceptual nature of these two heuristics refers to different cognitive processes, disentangle their empirical effects was trickier than initially expected and left important research questions unanswered: When are representativeness and availability used? How can these heuristics be empirically distinguished and their conceptual definitions clearly articulated? The main goal of the present article is to give a first step on resuming the initial promising work on the availability and representativeness heuristics and tackle the view that portrayed the heuristics as vague and overlapping constructs with little explanatory value.

### **Theoretical Problem**

According to Tversky and Kahneman initial proposal, representativeness is defined in terms of a similarity assessment between the target instance and a category in memory. Probability judgments are based on the extent to which the target matches, or represents the central attributes of the subjective category (Kahneman & Tversky, 1972). Availability is defined in terms of mental sampling (bringing to mind, examples of the target population) whereby the judged likelihood of an event depends on the ease of retrieval of a category's specific instances or the accessibility of these instances in memory (Tversky & Kahneman 1973).

As aforementioned, despite obvious conceptual differences, in the original definitions of representativeness and availability, judgments, decisions and biases associated to one of the heuristics could often be explained by the other. For instance, if asked if there are more deaths by rattlesnake bites or bee stings one may answer based on which of these animals is more representative of (more similar to) a dangerous animal (a judgment by representativeness). Alternatively, one's response may be based on memory accessibility for deaths caused by rattlesnake bites or bee stings. Since snakes are likely to be perceived as more dangerous than bees and to the extent that deaths by snake bites are more cognitively accessible events than deaths by bee stings, both heuristics would predict the same answer. Now, imagine you recently saw a movie about killer-bees, increased events accessibility portraying bees as really threatening, may lead you to judge that there are more deaths by bees' stings than by rattlesnakes' bites. However, one could equally argue that as a consequence of the film you now find bees more representative of a dangerous animal than rattlesnakes (Anderson, 1990).

Somewhat intriguingly, research efforts aimed at disentangle availability from representativeness (e.g., Corts & Sherman, 1984) were mostly abandoned in the last decades.

### **Disentangling representativeness and availability**

Our main goal is to empirically disentangle representativeness from availability, and conceptually clarify these two heuristics

Our starting point is the conceptual framework put forward by Sherman and Corts (1984) suggesting that differences between representativeness and availability are akin to a contrast between two category learning models: prototype models – according to which people abstract a measure of central tendency of a category and base their categorical judgments on this central tendency or prototype (e.g. Posner & Keele, 1968) – and exemplar models – according to which categorization is based on similarity with specific exemplar information (e.g. Medin & Schaffer, 1978).

The main issue is then whether knowledge underlying judgment under uncertainty is a general abstraction built up from previous experiences or is a function of more specific instances. Along those lines we take representativeness as a heuristic based on categorical information, relying on a judgment of similarity between a stimulus and its prototype (Sherman & corts, 1984). On the other hand, judgments by availability should be considered as a direct effect of accessibility based on the sampling of cognitively accessible specific instances, and thus resembling one of the original definitions of this heuristic (e.g., Gabrielcik & Fazio, 1984; Hertwig, Herzon, Schooler, & Reimer, 2008).

It follows from the above that in circumstances where such definitions hold, availability should be a cognitively simpler heuristic than representativeness as the latter

involves more complex mental operations (abstract comparison of the given information with a prototype, general process or category's central tendency).

Past research already provides some evidence in agreement with such conceptual framework. For instance, Kubovy (1977) primed participants with digits and then asked them to give the first digit that came to mind. He suggests that in making such a choice subjects first consider the most available digit. At a second stage, they judge whether the first digit generated is representative of a spontaneous act. If it is judged as spontaneous, then it is given as a response. If not, the subject will generate a new digit. Kubovy then showed that when the prime was subtle (e.g., "Give the *first* digit that comes to mind" a sentence that subtly primed number 1), the primed digit became more available, was judge as representative of a spontaneous act, and was given as a response. However, when the prime was unsubtle (e.g., "Write down the first number that comes to mind...like 1"), although still easily accessible, the primed digits were not given as an answer probably because they were considered *non-representative* of a spontaneous act, suggesting that a judgment mostly stemming from availability was replaced by one based on representativeness (Kubovy, 1977). Additional research has extended and broaden Kubovy's results by consistently showing that mere exposure increases events' cognitive accessibility, making them more available for subsequent judgments (e.g., Higgins, 1996; Kahneman, 2003), whereas matching a category's central features to observed events often involves extra cognitive steps of mental abstraction and comparison (e.g., Kahneman & Frederick, 2001; Spears, Haslam, & Janse, 1999; Brainerd, Reyna, & Forrest, 2002;). Hence, any variables interfering with such extra steps may constrain the use of representativeness while favoring availability, thus contributing to disambiguate their relative impact on judgment under uncertainty.

### **What's next paradigm**

To achieve our goal of disentangling availability from representativeness it is crucial to use decision problems approachable by both heuristics but producing different outcomes. One decision paradigm that satisfies such methodological constraint is the prediction of binary outcomes (e.g., Oskarson, Van Boven, McClelland, & Hastie, 2009). In this “what’s next” paradigm participants observe a sequence of a binary outcome (e.g., a sequence of coin tosses) and then are asked to guess what is the next outcome (heads or tails). When evaluating sequences generated by a random mechanism (e.g., a fair coin), people show negative recency or gambler’s fallacy (e.g., Tversky & Kahneman, 1971). In other words, people tend to believe that the chance of getting a tail while tossing a fair coin increases after a sequence of three heads despite the fact that tosses are independent of the other tosses and the probability of a head or tail is constant at .50, regardless of previous outcomes.

This response pattern has been considered by some authors as a manifestation of representativeness heuristic (e.g., Tversky & Kahneman, 1971). Accordingly, participants estimate the extent with which the observed sequence matches their prototypic representation of a “coin toss”, which is expected to be 50% heads and 50% tails (or very close to it) even in relatively small sequences (Kahneman & Tversky, 1972); and to include more alternations and less streaks than is actual de case (see Lopes, 1982; Wagenaar, 1972). As a result, subjects believe that any toss will bring the overall level of heads and tails closer to the expected value of 50%, leading to compensatory predictions in new independent tosses.

However, as a streak of “heads” (or “tails”) unfolds, this increasingly salient outcome becomes cognitively more accessible, and available for the decision. Why then in this case people do not respond with their most available answer (e.g., guessing “heads” after a streak of heads)? In our view this is because in the standard use of the

“what’s next” paradigm (see Oskarson et al. 2008) people responses are made in conditions of full attention with no time constrains. In such cases the availability of “heads” response during the decision is likely to be replaced for the most *representative* option, “tails” (since this response allows the observed sequence to better conform with subjective expectancies of randomness). According to our theoretical proposal, any conditions that prevent or makes it difficult to compare the observed sequence with its abstract representation (such as cognitive load conditions), should reduce the reliance on judgments by representativeness. In those circumstances, predictions of the next outcome are expected to be more often based on the most cognitively available exemplars (streak exemplars) thus reducing the negative recency responses.

## **2. Study 1**

In the present study, we tried to disentangle availability from representativeness using the aforementioned “what’s next” paradigm.

We presented participants with streak (sequences that terminate with repetitions of the same outcome) and non-streak sequences (sequences that have a large number of alternations).

For streak sequences participants are expected to predict the end of the streak in a subsequent toss, showing the gambler’s fallacy according to the use of representativeness heuristic. Yet, whenever the presentation of the sequence and the decision are made under time constrains, we expect participants to have more difficulties to rely on representativeness, i.e., comparing the observed sequences with their mental prototypical representation. In such cases, decisions are more likely to be

based on availability heuristic, relying directly on the most salient and accessible response option, and thus favor more often the continuation of that streak.

For non-streak sequences, however, the same sequence presentation and response speed manipulations should have no effects since there is no basis either to use representativeness or availability.

Moreover, as availability depends on the saliency of exemplar information, we further expect that when the presentation format of the sequence increases the saliency of the streak, it should be easier to use that salient information in the following prediction to continue the streak under speeded presentation and response conditions. Therefore, the expected differences between fast and slow conditions should be larger for salient than for less salient presentations of the sequences.

Finally, presenting the sequences unfolding to create a string with all the outcomes is a more salient presentation format of the sequences than presenting each outcome, 1-by-1, alone in the center of the screen (e.g., Baron, 2008). Therefore, for streak sequences we expect the difference between fast and slow conditions to be larger for string than for 1-by-1 presentations. In contrast, for non-streak sequences no effects of presentation format are expected.

## **Method**

### **Participants**

Seventy-three students from Indiana University were presented with two sets of “what’s next?” decision tasks and assigned to one of four conditions. Due to technical problem information concerning participants’ gender and age was not registered.

### **Procedure**

Participants were told they would see sequences of tosses of a fair coin randomly withdrawn from an overall sequence of 1000 tosses. For each sequence, they were asked to predict the next outcome of the sequence right after the presentation of a response indicator (“???”) on the screen. To give their response they pressed a key tagged with an “H” to respond “head” or a key tagged with a ”T” to respond “tail”,. The response indicator was presented immediately after the last outcome of the sequence, and was placed where the next outcome should be presented. Participants were also told about two speed and response-time conditions under which they had to do the task. In one condition they were told that each outcome of a sequence would unfold very quickly, with less than half a second between outcomes (450ms), and that they also have to give their response at the same pace. In the other condition they were told the sequence would unfold with one second between each outcome, and after the last outcome they had about 5s to answer. Before each response-time condition participants had a training set of 6 sequences in order to get used to the task speed. All participants were presented with both speed conditions, counterbalanced for order of presentation and saw the same sequences in both conditions.

## **Materials**

### *Sequences*

Participants were randomly assigned to one of two sequence length conditions. In one condition 16 sequences of 4 outcomes were presented. In the other condition 20 sequences of 8 outcomes were presented. Using sequences of 4 and 8 allowed us to test the predicted decrease of negative recency with fast/salient streaks in a more general manner (independently of a particular number of outcomes on a sequence).

Sequences were selected in such a way that participants saw streak-sequences and non-streak sequences. Streak sequences are those with a minimum of 2 consecutive repeated

outcomes at the end of the sequence. Non-streak sequences terminate with an alternation.

For sequences of 4, all 16 possible combinations and arrangements between the two possible outcomes were used and presented to participants assigned to that condition. Sequences of 8 were defined using different probabilities of alternation ( $P(A)$ ) (Gronchi & Sloman, 2008)<sup>5</sup>. Twelve even sequences, (i.e., sequences with 4 heads and 4 tails), using 6 different values of probability of alternation ( $6/7$ ,  $5/7$ ,  $4/7$ ,  $3/7$ ,  $2/7$  and  $1/7$ ), were used. Also 8 uneven sequences, (i.e., sequences with 3 heads and 5 tails or 3 tails and 5 heads) using two different probability alternations values (6 sequences with  $P(A)=6/7$  and 2 sequences with  $P(A)=1/7$ ) were used. By combining even and uneven sequences we wanted to avoid any suspicious of non-randomness that looking always at sequences with the exact same number of heads and tails might have risen.

Participants assigned to the *sequence of 4* condition saw 8 streak sequences, 8 non-streak sequences, in a total of 16 sequences per response-time condition. Participants assigned to the *sequence of 8* condition were presented with 10 streak sequences (6 even sequences with  $P(A)$  between  $1/6$  and  $3/6$ , and 4 uneven sequences with  $P(A)=1/7$ , and  $6/7$ ) and 10 non-streak sequences (6 even and 4 uneven sequences with  $P(A)$  between  $4/7$  and  $6/7$ ), in a total of 20 sequences per response-time condition.

All sequences were presented in a random order.

The training trials used 6 non-streak sequences presented in random order.

Overall participants saw the same number of heads and tails. The same sequences were presented for both speed conditions, so participants saw each sequence twice (see Appendix A).

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<sup>5</sup>  $P(A)$  is the ratio between the actual changes and the total number of transitions. As an example, having 8 elements, TTTTHHHH has 7 transitions but only a single actual change between elements (the fourth T followed by the fifth H), thus  $P(A) = 1/7$ .

### *Presentation Formats*

Participants were randomly assigned to the *string* presentation format, in which the outcomes of a sequence unfold one after another creating a string with all the outcomes of that sequence on the screen; or to the *1-by1*, presentation format in which each outcome was presented, individually and alone on the center of the screen.

### **Design**

The design was a 2 X 2 X 2 X 2 X 2 factorial with Sequence length (4 vs. 8), Presentation format (string vs. 1by1), Task-speed order (fast-slow vs. slow-fast) as between subject-factors, and Sequence type (streak vs. non-streak) and Task-speed (fast vs. slow) as a within-subject factors.

### **3. Results**

To analyze the data we first computed for each participant the proportion of times a streak was completed with a response that continue the streak. For comparative purposes, we also computed the proportion of times a “non-streak” sequence was completed with a repetition of its last outcome.

An ANOVA with 2 sequence length (4/8 outcomes) x 2 presentation format (1by1/string) x 2 task-speed order x 2 task-speed conditions (slow/fast) x 2 sequence type (Streak/No-Streak), with repeated measures on the last two factors, revealed one main effect for the sequence type ( $F(1,69)=26.19$ ;  $p<.01$ ), suggesting that for streak sequences, participants are more willing to predict an alternation ( $M=.32$ ,  $SD=.03$ ), when compared with non-streak sequences ( $M= .45$ ,  $SD=.03$ ). No more significant effects were found.

We predicted that, for streaks, time constraints should affect the use of a categorical abstract representation of the event thus reducing the negative recency and allowing the manifestation of a response based on the most accessible exemplar information. To test for this prediction we used two-tailed planned-contrasts, pitting fast against slow conditions for both types of sequences and presentation formats.

As predicted participants were more willing to continue the streak under fast conditions ( $M=.35, SD=.24$ ) than under slow conditions ( $M=.29, SD=.21$ ) thus reducing the gambler's fallacy as indicated by the marginally significant planned contrast ( $F(1,69)= 3.25; p= .07$ ). No significant differences were found between fast ( $M=.44, SD=.24$ ) and slow ( $M=.45, SD=.19$ ) conditions for non-streak sequences ( $F(1,69)=.02, p=.88$ ) (see table 1).

Table 1 *Proportion of continuation responses for streak and non-streak sequences for slow and fast conditions.*

Streak	Non-streak				
	Condition	Mean	SD	Mean	SD
Slow	.29	.02	.44	.03	73
Fast	.35	.02	.45	.02	73

A plausible alternative explanation of the above results would be to argue that time-pressure was so severe that participants were simply unable to respond meaningfully ending up randomly pressing the keys. Note that an increase in random responses alone is enough to account for a reduction in negative recency for streak sequences due to regression to the mean.

However, regression to the mean should depend solely on increased speed, whereas an explanation based on availability should also depend on the salience/accessibility of the information. Consequently, we predict that if availability (and not regression to the mean) is the responsible mechanism for the present results, then decrease of negative recency should occur for string but not for 1by1, or at least to be stronger for the former.

As predicted, when facing streak sequences, participants were significantly more likely to continue the streak for fast conditions ( $M=.34$ ,  $SD=.04$ ) than for slow conditions ( $M=.25$ ,  $SD=.04$ ), when sequences were presented in a *string* ( $F(1,69)=4.4$ ;  $p<.05$ ), but no such difference between fast ( $M=.34$ ,  $SD=.03$ ) and slow ( $M=.35$ ,  $SD=.04$ ) conditions was found when the sequences were presented *1-by-1* ( $F(1,69)=.19$ ;  $p=.66$ ) (see table 2).

Table 2 *Proportion of continuation responses for streak sequences presented 1-by-1 and in string formats for slow and fast conditions.*

Condition	Slow		Fast		N
	Mean	SD	Mean	SD	
String	.25	.04	.34	.04	39
1-by-1	.34	.03	.35	.04	34

In sum, the present results support our prediction that under time-pressure participants are less prone to give negative recency responses. Such reduction of negative recency seems to depend on the salience and consequent accessibility of the information that follows the streak, thus giving some support to our hypothesis that

when Judgments by representativeness are prevented participants responses are more often dominated by the availability heuristic.

#### **4. Discussion**

The present study may be seen as a first step to empirically disentangle representativeness from availability.

Our results not only replicated the gambler's fallacy effect so many times found in previous research (for a review see Oskarson et al., 2008) but also, and more importantly, showed that this robust effect can be attenuated in a predictable way when participants have to decide under time-pressure conditions, particularly when the information is made more salient.

Representativeness is usually considered to account for the gambler's fallacy effect. However, the use of this heuristic to predict the next outcome of a sequence seems to depend on the ability to compare the observed stimulus sequences with its mental prototypical representation. In circumstances where this process is difficult, as in the fast conditions of the present study, negative recency tends to decrease. Judgments by representativeness seem to be replaced by other judgments directly based on the most easily accessible exemplar information – availability – thus leading to more streak continuations or positive recency responses when exemplar information is made salient. We suggest that the availability heuristic (as defined here) plays a role in this binary choice task that becomes directly observable only when judgments by representativeness are impaired.

Moreover, this results seem to be in line either with earlier studies on probability learning (e.g., Edwards; 1961; Feldman, 1959; Lindman & Edwards, 1961; Derks,

1962) showing positive recency and overmatch in binary prediction tasks essentially due to fatigue or stress; developmental studies, showing that negative recency behavior, may be the result of more sophisticated processes than positive recency, (e.g., Derks & Paclisanu, 1967; Jones & Liverant, 1960); as well as some recent studies on judgment and decision making (e.g., Hertwig Pachur & Kursenauer, 2005; Perruchet, Cleeremans, & Destrebecqz, 2006; Barron & Yechiam, 2009; Militana, Wolfson, & Cleaveland, 2010).

For instance, in a recent study with gambling decisions using a experimental paradigm very different from ours, Militana and colleagues (2010) found that at shorter intervals between choice allocations subjects were less likely to express the gambler's fallacy and more likely to express positive recency.

Note, however that these are preliminary results, which means our hypothesis need further tests. For instance, we would like to replicate the present results using, different manipulations of salience as alternative ways of constraining the reliance on representativeness and allowing responses to be more often dominated by the availability heuristic. Also, since we argue that the use of availability is dependent on the accessibility of specific instances that were made salient and representativeness depends on abstract representations, construal level manipulations (e.g., Trope and Liberman, 2000) could be quite useful as a way to influence the degree of accessibility and reliance on concrete exemplars or more abstract information in judgment under uncertainty.. Furthermore, our research on representativeness and availability will certainly profit from more direct tests of the processes we suggest to underlie each of the heuristics.

In conclusion, our current attempt at conceptually clarifying both heuristics has received some initial empirical support, which allowed for a small but important first

step towards disentangling representativeness from availability and thus refreshing the interest in the classical heuristics of judgment under uncertainty.

**Chapter IV: What's next, disentangling availability from representativeness using binary decision tasks. – Braga, J., Ferreira, M. B., Sherman, S. J., & Mata, A. (invited for resubmission – *Journal of Experimental Social Psychology*)**

**1. Introduction**

What is the next outcome of a coin toss in a sequence? Will it rain tomorrow? Are there more deaths caused by heart attacks or lung cancer? Since the 70's, based on work by Tversky and Kahneman, the representativeness and the availability heuristics are assumed to play a role in the processes underlying these and other common intuitive predictions or judgments (e.g., Kahneman & Frederick, 2002; Tversky & Kahneman, 1974). These authors challenged the use of rational models as explanations for human judgment and suggested that simplifying heuristics (qualitatively different from normative models) underlie most human judgments under uncertainty. Although conceptually these heuristics are thought to rely on different cognitive processes, disentangling their empirical effects proved to be trickier than initially expected and left important research questions unanswered: When are representativeness and availability used? How can these heuristics be empirically distinguished and their conceptual definitions clearly articulated (see Anderson, 1990; Kahneman & Frederick, 2002; Sherman & Corty, 1984)?

When Representativeness, When Availability?

In the heuristics-and-biases research program, the conceptions of representativeness and availability were outlined by clearly different definitions. Representativeness was defined in terms of a similarity assessment between the target instance and a category in memory, and judgments would then be based on the extent to which the target matches or represents the attributes central to the subjective category

(Kahneman & Tversky, 1972). For instance, after a streak of three “heads”, the next outcome of a coin toss is expected to be a “tail” and end the streak (the gambler’s fallacy), because the observed streak is not representative of people’s subjective notion of a binary random event (Kahneman & Tversky, 1972; Tversky & Kahneman, 1971), which is expected to have very few streaks and to be approximately 50% heads and 50% tails even in small samples (e.g., Bar-Hillel & Wagenaar, 1991; Lopes & Oden, 1987; Wagenaar, 1972).

On the other hand, availability was defined in terms of the mental sampling of specific exemplars, whereby the judged likelihood of an event depends on the ease of retrieval or the accessibility of these specific instances (Tversky & Kahneman, 1973). As an example of the direct effect of accessibility, exposing subjects to subliminally presented words containing the letter t increased frequency estimations of words beginning with “t” (Gabrielcik & Fazio, 1984).

One crucial conceptual difference between these two heuristics is that availability relies on the accessibility of instances whereas representativeness depends on matches with abstract representations. Theoretical efforts to understand and disentangle these two heuristics suggested that the use of either representativeness or availability would depend on the accessibility of, respectively, categorical information (representations) or specific instances (e.g., Kahneman & Frederick, 2002; Sherman & Corty, 1984). In fact, priming abstract mindsets (high levels of construal, which facilitate similarity judgments and the reliance on abstract information) has been shown to increase the use of the representativeness heuristic in base-rate or conjunction problems, whereas concrete mindsets (low levels of construal, which focus on concrete specific instances) increase reliance on the availability heuristic (Braga, Ferreira, & Sherman, 2015).

However, despite the aforementioned differences, the same problem can elicit and make accessible both categorical and exemplar information. For example, if asked whether there are more deaths caused by rattlesnake bites or bee stings, one may answer based on the memory accessibility of instances of deaths caused by rattlesnake bites or bee stings (a judgment by availability). Alternatively, one's response may be based on which of these animals' representations is more representative of (i.e., more similar to) a dangerous animal (a judgment by representativeness). Assuming that snakes are perceived to be more similar to the representation of a dangerous animal than bees, and to the extent that deaths by snakebites may be more cognitively accessible events than deaths by bee stings, both heuristics would predict the same answer. This example, offered by Anderson (1990), clearly illustrates that it is often difficult to identify *a priori* which heuristic –representativeness or availability – is going to underlie the judgment behavior, although both heuristics can, *a posteriori*, be used to explain the same judgment (Gigerenzer, 1991, 1996).

But even in such cases where both heuristics apply, representativeness and availability should nonetheless rely on a different processing of the same information. Availability relies directly on the accessibility of target instances to generate a response (e.g., predicting “heads” on a coin toss – “heads or tails?” – because “heads” comes to mind sooner than “tails”; Bar-Hillel, Peer, & Acquisti, 2014), whereas representativeness involves the comparison of the target with a representation (in the gambler's fallacy example this requires not only processing the observed streak, but also comparing it to a representation of random binary events). Therefore, when both heuristics can be computed, availability judgments, being a direct effect of accessibility, should be completed before judgments by representativeness, which involve not only assessing the target but also comparing it with an abstract representation.

However, when such a comparison is completed, the representativeness-based response takes precedence over availability-based responses. Indeed, research on the availability heuristic shows that, if participants are aware of an alternative explanation for an item's accessibility, the effect of accessibility disappears (Kubovy, 1977; Oppenheimer, 2004; Schwarz, 1998; Schwarz et al., 1991; Waenke, Schwarz, & Bless, 1995). For instance, when judging the frequency of certain letters in a text, participants overestimate the frequency of their own name's initials (because our own name initials are chronically accessible), but underestimate their frequency if they had previously used their initials in an unrelated task (Oppenheimer, 2004, Study 3). These results suggest that, even though specific instances are accessible, people do not necessarily rely on the availability heuristic (e.g., Gabrielcik & Fazio, 1984; Oppenheimer, 2004). They may discount the direct effect of accessibility and rely on other judgment processes, such as representativeness (e.g., Kubovy, 1977).

On the other hand, reliance on the representativeness heuristic seems to be constrained by time-pressure manipulations during the processing of the target-problem (Villejoubert, 2009). For instance, the conjunction fallacy, an effect attributed to the use of representativeness (Tversky & Kahneman, 1973), was found to be reduced when the time to process and respond to the conjunction problem was constrained (Villejoubert, 2009). This result is consistent with the idea that heuristic responses requiring the processing of the target *and* its matching with a representation (representativeness) need more processing time to be fully computed than relying directly on the accessibility of instances (availability).

We thus suggest that the processing time conditions, and not only the accessibility of information (Kahneman & Frederick, 2002), determine whether judgments rely on availability or representativeness. Decision contexts amenable to both

heuristics, but where the responses suggested by the two heuristics are in opposition, provide an ideal setting to test the above hypothesis by directly pitting availability against representativeness.

#### “What’s Next” Paradigm: Alternation vs. Continuation

Tasks that require predicting the next outcome in a sequence of outcomes satisfy our methodological needs. As mentioned before, after a streak of three consecutive “heads” generated by a coin toss, people show a tendency to predict the opposite outcome (tails, the gambler’s fallacy). This tendency has been seen as a manifestation of the representativeness heuristic (Tversky & Kahneman, 1971; but see Oskarsson, Van Boven, McClelland, & Hastie, 2009, for a review of different accounts). Because participants compare the observed sequence with a representation of a binary random event (50% heads and 50% tails, and few streaks), they expect a new toss to bring the overall level of heads and tails closer to the expected value of 50% every time the observed sequence deviates from that representation (Kahneman & Tversky, 1972).

On the other hand, as a streak of “heads” unfolds, this outcome becomes cognitively more accessible. However, people do not rely directly on the most available answer (e.g., guessing “heads” after a streak of heads)<sup>6</sup>. This may be because, in the standard use of this “what’s next ?” paradigm, people have the time to compute the comparison between the observed sequence and the representation of the event, thus replacing the availability of “heads” with the more “representative” option, “tails”.

In order to empirically disentangle these two heuristics, in three studies using the “what’s next” paradigm, we test the hypothesis that judgments by availability

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<sup>6</sup> Note that predictions of streaks’ continuation relying on availability differ from the process underlying the hot-hand effect, since the latter effect holds for generating mechanisms that are perceived as intentional (Caruso, Waytz, & Epley, 2010), non-random (Tyszka, Zielonka, Dacey, & Sawicki, 2008), or skilled (Ayton & Fisher, 2004), which is not the case for our coin toss scenario. A more detailed discussion about the hot-hand can be found in the discussion section.

(predicting a streak's continuation) are computed more quickly than judgments by representativeness (predicting a streak's end) and that processing-time constraints affect the use of representativeness but not of availability.

In Study 1 we tested whether responses rely on the mechanism proposed by representativeness even if availability is being computed and suggests a different answer. Moreover, we tested whether predicting an alternation after a streak (representativeness) takes longer to compute than predicting a streak's continuation (availability). Study 2 manipulates the speed of a sequence's presentation and participants' response time in order to impede the use of representativeness (e.g., Villejoubert, 2009). However, such processing constraints should not affect the direct use of outcomes' accessibility – availability. Study 3 further tests our hypothesis by presenting the sequences subliminally (e.g., Gabrielcik & Fazio, 1984). If streak sequences are presented outside of awareness, we expect participants' predictions to become exclusively driven by availability because streaks' outcome accessibility increases, whereas the representativeness heuristic will not be triggered because participants will not have conscious access to the presented sequence in order to compare it to a representation.

## **2. Study 1**

This study aims to test whether predictions after a streak are generally based on representativeness and lead to the streak's end, even though a response based on the most accessible outcome (availability) would predict a streak's continuation. We tested this by either asking participants to predict the next outcome or by directly asking them about the most easily accessible outcome in their minds. Moreover, if availability relies

directly on the accessibility of instances and representativeness requires an extra-step of computing the similarity with a representation, then we should expect that continuation responses, driven by availability, will be computed faster than alternation responses, driven by representativeness. Finally, Study 1 attempts to collect further evidence for the general use of representativeness in this predictive task by testing whether participants' judgments about the randomness of the observed sequence after a prediction are facilitated (i.e., are faster) when these judgments require the same comparison with a representation of a random binary event that is argued to underlie representativeness.

## **Method**

### **Participants**

Sixty-three (36 female) students, mean age 20 ( $SD = 1.15$ ), from Indiana University participated in this experiment and received one credit for their participation.

### **Procedure**

Participants were informed that they would see sequences of tosses of a fair coin. After each sequence, they were asked to respond to one question and make one judgment about the sequence. Each outcome of a sequence was presented individually on the center of the computer screen for 2750ms and then replaced by a mask ("XXXX") for 2000ms. The last mask of a sequence was then replaced by one question requiring a "head" or "tail" response. After responding to the question, participants were asked to make a subsequent judgment on a seven-point rating scale.

Questions. For each sequence, participants were either asked to predict the next outcome of the sequence ("What's the next outcome of the sequence?" (WN), or to select the most accessible outcome ("What's the most accessible outcome in your

mind?” (WA). Two filler questions (“what was the first/last outcome of the sequence?”) could also be presented to prevent participants from engaging in any strategic processing of the sequences.

**Judgments.** After each question, participants were sometimes asked to compare the observed sequence with their representation of a random event by judging how random looking the sequence was on a scale from 1(not random looking at all) to 7 (extremely random looking). For comparative purposes, at other times, they were asked to make a judgment not related to representativeness: either to judge the confidence in their previous response or to judge the sequence’s length, on similar 7 point rating scales.

**Sequences.** All sequences had 8 outcomes and could either be streaks (i.e., sequences of a low probability of alternation<sup>7</sup> (Gronchi & Sloman, 2008) that ended with at least 3 consecutive repetitions of the same outcome) or non-streaks (i.e., sequences of a high probability of alternation that ended with an alternation). For each sequence arrangement there was a version in which “tails” were replaced by “heads”, so that participants were exposed to the same total number of “heads” and “tails” (see Appendix B). After 6 practice trials, participants were presented with 26 sequences. Questions and judgments were paired orthogonally for streak and non-streak sequences, so that participants responded to each of the 4 questions followed by each possible judgment for both streaks and non-streaks<sup>8</sup>.

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<sup>7</sup> P(A) is the ratio between the actual changes and the total number of transitions. As an example, having 8 elements, TTTTHHHH has 7 transitions but only a single actual change between elements (the fourth T followed by the fifth H). Thus, P(A) = 1/7

<sup>8</sup> Participants saw 2 extra sequences (one streak and one non-streak) with the combination of the predictive question followed by the judgment of “random looking”

## Design

The design was a 2 sequence (streak/non-streak) X 4 question (prediction/ accessibility/1<sup>st</sup> of the sequence/ last of the sequence) X 3 judgment (randomness looking/confidence/length).

The dependent variables were the proportion of responses selecting the last outcome of a sequence, the reaction times for predictive questions, and participants' judgments about the sequences.

## Results and Discussion

Prediction vs. Accessibility. A 2 question type (prediction/ accessibility) x 2 sequence (streak/non-streak) ANOVA was performed on participants' responses. We found a main effect of question type,  $F(1, 61) = 30.10, p < .001, \eta^2 = .99$ , showing that participants were more likely to select the last outcome of the sequence when asked for the most accessible outcome ( $M = .61, SE = .04$ ) than when they were asked to predict the next outcome of the sequence ( $M = .38, SE = .02$ ). This effect was qualified by an interaction with the type of sequence  $F(1, 61) = 29.48, p < .001, \eta^2 = .33$ . No other effects were found. Planned comparisons were used to test whether this difference between prediction and accessibility questions was specific for streak sequences. As expected, for streak sequences, participants alternated more when asked to predict what's next ( $M = .34, SE = .03$ ) than when they had to select the most accessible outcome in their minds ( $M = .72, SE = .04$ ),  $F(1,61) = 49.06, p < .001, \eta^2 = .45$ . However, such a difference was not found for non-streaks ( $M_{accessibility} = .49, SE = .04, M_{prediction} = .44, SE = .03$ )  $F(1,61) = 1.33, p = .253$ . In fact, for streaks, whereas participants alternated more than predicted by chance for what's next questions, one-

sample  $t(61) = -4.68, p < .001, d = .08$ , they selected the last outcome of the sequence, greater than chance, as the most accessible outcome in their minds, one-sample  $t(61) = 4.98, p < .001, d = .01$ . Responses for non-streaks did not differ from chance for accessibility questions,  $t(61) = -0.12, p = .901$ , and for prediction questions there was only a marginally significant difference,  $t(61) = -1.67, p = .099, d = .18$ .

These results show that, even though the repeated outcome in a streak was clearly more accessible (which is the basis for availability), participants often did not judge what's next on the basis of that accessible outcome, and they were likely to predict the streaks' alternation, which is consistent with representativeness.

Reaction times for prediction questions. In order to test whether predictions of alternations take more time to compute than predicting a repetition of the last outcome of the sequence, we compared the reaction times for responses that alternated the last outcome of the sequence with responses that continued the last outcome. For this analysis, reaction times for prediction questions were log transformed and 5% trimmed (e.g., Erceg-Hurn & Mirosevich, 2008).

A 2 sequence (streak/non-streak) x 2 response (alternation/continuation) ANOVA revealed a main effect of sequence type,  $F(1, 30) = 11.84, p = .002, \eta^2 = .28$ , such that predictions were faster for streaks ( $M = 2052.52\text{ms}, SE = 139.98$ ) than for non-streaks ( $M = 2581.74\text{ms}, SE = 168.42$ ). We also found a marginal interaction between sequence type and response  $F(1, 30) = 3.00, p = .094, \eta^2 = .09$ . No other effects were found. Planned contrasts<sup>9</sup> further show that, as predicted, for streak sequences, continuation responses were faster ( $M = 1919.53\text{ms}, SE = 189.35$ ) than alternating responses ( $M = 2185.52\text{ms}, SE = 146.97; F(1, 30) = 4.90, p = .034, \eta^2 = .14$ ).

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<sup>9</sup> All planned comparisons reported in Study 1 and the following studies are two-tailed.

However, no differences were found between response options for non-streak sequences ( $M_{\text{continuation}} = 2650.05\text{ms}$ ,  $SE = 225.89$ ;  $M_{\text{alternation}} = 2513.42\text{ms}$ ,  $SE = 167.52$ ;  $F(1, 30) < 1$ ).

These results suggest that responses based on representativeness, that is, responses alternating the streak, are slower to compute than responses relying directly on the last outcome of a streak (availability). The fact that this effect occurs only for streaks further supports the idea that the repetition of the outcome is increasing its accessibility, thus facilitating responses that continue the streak. Representativeness-based responses that do not rely directly on instances' accessibility, take longer to occur.

Reaction times for judgments. We examined whether, after a prediction, judgments of randomness were faster than questions not related to representativeness (judgments of confidence and length), which would provide further evidence of the use of representativeness in such a task. For this analysis, reaction times were log transformed and 5% trimmed. First, we verified that participants were, naturally, judging streak sequences as less random looking ( $M = 3.63$ ,  $SE = 0.15$ ) than non-streaks ( $M = 4.46$ ,  $SE = 0.16$ ;  $F(1, 61) = 22.84$ ,  $p < .001$ ,  $\eta^2 = .27$ ). We then performed a 2 question (prediction/ accessibility) x 2 sequence (streak/non-streak) x 3 judgment (randomness/confidence/length) ANOVA on judgments' reaction times. We found a main effect of sequence type,  $F(1, 36) = 6.20$ ,  $p = .018$ ,  $\eta^2 = .15$ , showing faster judgments for streaks ( $M = 2677.82\text{ms}$ ,  $SE = 107.19$ ) than for non-streaks ( $M = 3002.15\text{ms}$ ,  $SE = 134.60$ ). A main effect of question type  $F(1, 36) = 12.16$ ,  $p = .001$ ,  $\eta^2 = .25$ , was also found, such that participants made faster judgments after accessibility questions ( $M = 2657.18\text{ms}$ ,  $SE = 120.50$ ) than after prediction questions ( $M = 3022.79\text{ms}$ ,  $SE = 116.75$ ). More interesting is the observed interaction between question

and judgment type,  $F(2, 72) = 6.19, p = .003, \eta^2 = .15$  (see Table 1; no other effects were significant). This interaction suggests that judgments of randomness are faster, but not significantly so, when preceded by prediction vs. accessibility questions. In addition, judgments of randomness are faster than judgments of confidence and length, after a prediction question ( $F(1, 36) = 12.69, p = .001, \eta^2 = .26$ ), but not after an accessibility question ( $F(1, 36) = 1.66, p = .205$ ). This result supports the idea that representativeness, comparing the sequence with a representation of a random binary event, is used to predict the next outcome of a sequence, which facilitates subsequent judgments using the same representation when compared to judgments that do not use such representation. However, the information used for the accessibility question does not facilitate any particular judgment.

Table 1. *Reaction times for judgments of randomness, confidence and sequence length after predictive questions and accessibility questions. All values are in milliseconds.*

	Judgments		
	Randomness	Confidence	Length
Question			
Prediction	2535.68 (108.56)	2814.37 (155.49)	3718.31 (188.86)
Accessibility	3268.88 (188.33)	2905.50 (205.40)	3477.87 (357.50)

*Note: n = 37. Standard error in the parenthesis*

Results from Study 1 replicate the general use of the *gambler's fallacy* in a coin toss scenario, showing that, after a streak, participants predict an alternation, as

expected by the representativeness heuristic, even though responses based on the most accessible outcome would predict the streak's continuation. It further shows that predictions in such scenarios may indeed be based on representativeness (the comparison with a representation of this random event), since judgments of randomness about the sequence are facilitated by having previously been asked to predict the next outcome of the sequence. More important, in order to disentangle representativeness from availability, we found that after a streak, alternation responses, predicted by representativeness, take more time to be computed than continuation responses, predicted by availability. This suggests that the representativeness heuristic may have more processing steps (comparing the target with a representation) than availability (relying directly on the accessibility of instances).

### **3. Study 2**

In Study 1, we used reaction time as a dependent measure. Study 2 manipulates processing time to make a prediction. If representativeness takes longer to be computed, we should expect temporal constraints during processing and response generation to affect the use of the representativeness heuristic more than the use of availability, thus reducing predictions of alternations after a streak. Moreover, because the availability heuristic relies directly on the accessibility of instances, Study 2 also manipulates such accessibility. We expect that increasing the salience of streak outcomes will facilitate the use of availability, thus increasing the effect of time pressure on participants' predictions (i.e., more continuations of salient streaks under time pressure conditions and more alternations in the absence of time pressure). In Study 2, we presented

sequences in an unfolding string rather than presenting them one by one, and we used sequences of different lengths and alternation patterns.

## ■ Method

### Participants

Fifty eight (34 female) students, mean age 23.4 ( $SD = 4.8$ ), from the University of Lisbon participated in this experiment to meet course requirements.

### Procedure

Participants were informed that they would see sequences of tosses of a fair coin with different lengths. Their task was to predict the next outcome of each sequence. After the last outcome of a sequence, participants saw a response indicator (“???”) after which they had to press either a green key for “heads” or a red key for “tails”. The same participants took part in two different task-speed conditions. In the fast condition, they were told that each outcome of a sequence would unfold very quickly (every 450ms a new outcome was added to the sequence), and that they should give their response at the same fast pace (450ms). In the slow condition, they were told that the sequence would unfold with one second between each outcome, and that they had up to 5 seconds to give their response. Before they saw the critical sequences, participants went through a training set of 6 sequences.

Sequences. Participants were presented with 16 streak sequences and 16 non-streak sequences of 8 and 6 outcomes.

Outcome salience was manipulated in 4 streaks and 4 non-streaks by having the outcome with which these sequences ended presented in bold font style during the entire sequence (e.g., Tail-Tail-**Head-Head-Tail-Head**). Thus, for these sequences all “heads” or all “tails” were bold, which means that for streak-sequences the streak was bold.

Again, for each sequence arrangement, there was a version in which “Heads” replaced “Tails” so that participants were exposed to the same number of “heads” and “tails”. A total of 32 sequences were randomly presented in both task-speed conditions (Appendix C). The same sequences were presented for both speed conditions, so that participants saw each sequence twice. The order of task-speed conditions was counterbalanced between-participants.

### **Design**

The design was a 2 X 2 X 2 X 2 X 2 factorial with Task-speed condition order (1 vs. 2) as a between-participants factor, and Sequence type (streak vs. non-streak), Sequence length (6 vs. 8), Font (bold vs. non-bold), and Task speed (fast vs. slow) as within-participant factors.

The dependent measure was the proportion of predicted continuations of the sequences’ last outcome.

### **Results and Discussion**

An ANOVA with 2 task-speed condition orders x 2 task-speed conditions (slow/fast) x 2 sequence types (streak/non-streak) x 2 sequence lengths (6/8) x 2 sequence fonts (non-bold/bold), with repeated measures on the last four factors, revealed a single main effect of task-speed condition,  $F(1, 56) = 10.02$ ,  $p = .003$ ,  $\eta^2 = .15$ , showing more continuation responses for the fast condition ( $M = .46$ ,  $SE = .05$ ) than for the slow condition ( $M = .39$ ,  $SE = .05$ ). An interaction between task-speed and sequence type  $F(1, 56) = 10.01$ ,  $p < .003$ ,  $\eta^2 = .15$ , was also found. Planned-comparisons revealed that, for streak sequences, participants were more likely to predict the sequence continuation in the fast condition compared to the slow condition,  $F(1, 56) = 21.61$ ,  $p < .001$ ,  $\eta^2 = .28$ . No such difference between fast and slow conditions was

seen for non-streaks,  $F < 1$  ( $M_{fast} = .46$ ,  $SD = .04$ ;  $M_{slow} = .45$ ,  $SD = .06$ ). We also found a non-interpretable, but significant third order interaction between task-speed, order, and sequence font,  $F(1, 56) = 4.89$ ,  $p = .031$ ,  $\eta^2 = .08$ .

These results indicate that alternation responses, presumably based on representativeness, are sensitive to temporal constraints, which suggests that representativeness needs some time to be computed. Yet, time pressure decreased alternation responses only to values near chance, making it hard to argue that participants' responses are more likely to be driven by availability when there is not enough time to compute representativeness.

For streaks, even though time pressure increased continuation for both bold,  $F(1, 56) = 15.86$ ;  $p < .001$ ,  $\eta^2 = .22$ , and non-bold sequences,  $F(1, 56) = 8.05$ ,  $p = .006$ ,  $\eta^2 = .13$ , we found that this effect was stronger for bold than for non-bold sequences,  $F(1, 56) = 4.16$ ;  $p = .046$ ,  $\eta^2 = .07$ . For non-streak sequences there were no significant differences,  $F < 1$  (see Table 2). Such difference between bold and non-bold streak sequences suggests that the increase in continuation responses, due to the processing-time constraints, may be driven by availability because streak instances become more accessible when the sequence is bold. If time constraints were simply increasing random predictions by impeding the computation of representativeness, the effect of such a manipulation should have been the same whether instances were more (bold) or less (non-bold) salient. In sum, this interaction between task speed and font type for streaks suggests that increased salience facilitates the use of representativeness in the slow condition, but it facilitates the use of availability when the computation of representativeness is not concluded due to the time-pressure manipulation (fast condition).

Table 2. *Proportion of continuation responses for fast and slow conditions, for streak and non-streak; bold and non-bold sequences.*

	Non-Bold		Bold	
	Streak	Non-streak	Streak	Non-streak
Condition	Mean	Mean	Mean	Mean
Slow	.36 (.03)	.46 (.02)	.31 (.03)	.36 (.04)
Fast	.44 (.03)	.48 (.02)	.48 (.04)	.45 (.04)

*Note: N = 57. Standard error in parenthesis.*

In sum, results from Study 2 show that alternation responses are reduced, and continuation responses increased, by temporal constraints during processing and response generation. This suggests that, although heuristic processing is generally quite quick to produce an outcome, judgments by representativeness take somewhat more time to be computed than judgments by availability. It is worth noting, however, that participants' responses under time pressure were near chance level, and did not reverse to a continuation response pattern that would more clearly indicate the use of availability. On the other hand, the fact that this increase in continuation responses is stronger when instances are made particularly accessible (bold font) suggests that availability is used when participants do not have the time to compute representativeness.

#### **4. Study 3**

In Study 2, even under time pressure conditions, participants were clearly aware of the stimuli sequences while they unfolded, which may have facilitated the computation of representativeness. If that was the case, this may explain why continuation responses increased only to chance level under time pressure conditions. In fact, explicit access to the sequences is likely to be a pre-condition to engage in judgments by representativeness. Hence, a crucial test of the proposed use of representativeness versus availability is to block conscious access to the sequence of Heads and Tails. If conscious access to the sequence is blocked, not only does comparing the sequence to an abstract model of the event become impossible, but also the source of the most available responses resulting from streak presentations will be outside awareness. In fact, the subliminal priming of an outcome has been shown to increase its accessibility outside participants' awareness, leading to responses directly based on such outcome's availability (e.g., Gabrielcik & Fazio, 1984). Thus, in Study 3, we further test our hypothesis by including subliminal presentations of sequences in the same binary decision task. When streak sequences are presented subliminally, streaks should become easily accessible but without participants' awareness of the source of such accessibility, therefore impairing judgments by representativeness and reversing the gambler's fallacy.

#### **Method**

##### **Participants**

Forty-five (26 female) students, mean age 23 ( $SD = 5.2$ ), from the University of Lisbon participated in this experiment to meet class requirements.

## Procedure

The procedure was similar to that used in the previous studies. However, participants were told that the speed between each outcome of a sequence could randomly change between sequences, and sometimes the presentation would be so fast that they could not see which outcome was being presented. As in Study 1, each outcome of a sequence was presented individually on the center of the screen, followed by a mask (“XXXX”). The last mask was then replaced by the response signal “???”. After the response, a new sequence appeared on the screen. Participants always had 5 seconds to give their answer.

**Materials.** Participants were presented with a total of 7 different sequences under three speed of presentation conditions: *slow condition*, where each outcome was presented for 3000ms; *fast condition*, where each outcome was presented for 1000ms; and *subliminal condition*, where each outcome was presented for 33ms (e.g., Mussweiler & Englich, 2005).

We used the same streak and non-streak sequences as in Study 1 and presented them in both the 1-second and 3-second conditions. For the subliminal condition, and in order to prime only one of the outcomes (heads or tails), we presented two perfect streak sequences of 12 equal outcomes, and another “non-streak” sequence of 12 consecutive fillers (“Cnmn” – the filler was chosen in such a way it would be perceptually similar to both outcomes). We used fillers rather than actual heads/tails for the non-streak subliminal sequence to prevent participants from detecting any differences between the outcomes of a sequence in the subliminal condition that could be interpreted as suggesting alternation. Each sequence was presented twice except the non-streak filler sequence, which was presented 4 times. Therefore, participants saw a total of 24 sequences. (Appendix B)

All sequences and speed conditions were presented in a random order.

## Design

The design was a factorial 2X3 with two sequence types (streak vs. non-streak) and three presentation speed conditions (slow vs. fast vs. subliminal) within-subject factors.

## Results and Discussion

An ANOVA with 2 sequence types (streak/non-streak) x 3 presentation speeds (slow/fast/subliminal) revealed a main effect of presentation speed,  $F(2, 88) = 8.13$ ,  $p < .001$ ,  $\eta^2 = .16$ , showing that, as the speed of presentation increased, the more likely were predictions of continuation ( $M_{slow} = .37$ ,  $SE = .037$ ;  $M_{fast} = .46$ ,  $SE = .03$ ; and  $M_{subliminal} = .53$ ,  $SD = .02$ ). This main effect was qualified by an interaction between presentation speed and sequence type,  $F(2, 88) = 6.10$ ,  $p = .003$ ,  $\eta^2 = .123$ , showing that the effect of speed of presentation was stronger for streaks than for non-streaks (see Table 3).

Table 3. *Proportion of continuation responses for streak and non-streak sequences for slow, fast, and subliminal presentations*

Condition	Streak	Non-streak
	Mean	Mean
Slow	.33 (.04)	.42 (.05)
Fast	.41 (.05)	.50 (.03)
Subliminal	.59 (.04)	.47 (.02)

Note:  $N = 45$ . Standard error in parenthesis.

More importantly, planned comparisons specifically testing our hypothesis replicated the effect of time pressure on predictions that was found in Study 2. Participants were more likely to continue the streak for fast presentations than for slow presentations of the sequence,  $F(1,44) = 3.60, p = .064, \eta^2 = .08$ . No differences were found for non-streaks,  $F(1,44) = 2.34, p = .133$ . As in Study 2, the moderately fast presentation of sequences (fast condition) increased continuation responses, but did not reverse the gambler's fallacy response pattern. Moreover, for streak sequences, comparisons between subliminal presentations and both 3-second,  $F(1,44) = 22.14, p < .001, \eta^2 = .33$ , and 1-second presentations,  $F(1,44) = 9.97, p = .003, \eta^2 = .18$ , showed significantly more continuation responses for subliminal presentations. In fact, a one-sample t-test shows positive recency (more continuations than predicted by chance) for subliminally presented streaks,  $t(44) = 2.28, p = .027, d = .04$ , whereas slow ( $t(44) = -3.86, p < .001, d = .04$ ) and fast ( $t(44) = -1.79, p = .081, d = .08$ ) conditions exhibited negative recency (more alternations than predicted by chance), though marginally for the latter. No differences were found for non-streak sequences between subliminal, fast, or slow conditions (both  $F_s < 1$ ). Responses to non-streaks were not different from chance,  $t_s \leq 1.66, p_s \geq .104$ . These results indicate that, for subliminally presented sequences, when participants have no conscious access to the sequence, they are more likely to predict a streak's continuation, thus reversing the gambler's fallacy effect.

Study 3's results are thus supportive of our hypothesis. In conditions of full attention and processing time, participants use representativeness to predict alternation; but, as the time to compute the sequence is constrained, the use of representativeness is reduced. Particularly, when streak sequences are presented outside participants' awareness, assessing these sequences' randomness by representativeness is no longer possible. Participants are left with a highly accessible outcome but without clear access

to the source of such accessibility. This situation increased reliance on the availability heuristic to predict the streak's continuation, thus reversing the gambler's fallacy. In sum, these results suggest that representativeness requires computational steps not needed to compute a response by availability. Therefore, if instances are accessible and representativeness cannot be computed, predictions will be based on the availability heuristic.

## **5. General Discussion**

Research on judgment and decision making has portrayed the availability and representativeness heuristics as vague and overlapping constructs (e.g., Gigerenzer, 1991, 1996). We argued that, when both abstract representations and specific instances are accessible, relying directly on the availability of those specific instances requires one fewer computational step (i.e., the matching with a subjective representation of a random sequence) and is, therefore, faster to compute than representativeness. Using a binary decision task paradigm, we found evidence indicating that representativeness guides decisions to predict a streak's alternation, but representativeness is sensitive to processing-time constraints. Availability requires less processing time to predict a streak's continuation.

Results from Study 1 show that predictions of the next outcome of a coin toss are based on the representativeness heuristic, relying on the most representative outcome, which alternates the streak, and not on availability, relying on the most easily accessible outcome, which would predict the streaks' continuation. It further suggests that availability is computed earlier than representativeness, as responses predicting a streak's continuation are computed faster than predictions of alternation.

Studies 2 and 3 further tested this hypothesis and revealed that temporally constraining the processing of the sequences reduced predictions of a streak's alternation, suggesting that the representativeness heuristic takes time to compute the comparison of the target with a representation of the event. This result is in line with previous research suggesting that the use of representativeness in conjunction problems is reduced under time-pressure conditions (Villejoubert, 2009). On the other hand, Studies 2 and 3 also suggest that, when representativeness cannot be computed, predictions may be driven by availability if instances are accessible.

Study 2 showed that the reduction of the gambler's fallacy was stronger when the streak was made particularly salient, a condition that should increase the use of availability. Study 3 showed that subliminal presentations of the streak reversed the gambler's fallacy, and participants were more likely to predict a streak's continuation than its alternation. Because participants were not able to compare the sequence to a representation, they relied directly on the accessibility of the primed outcome, as predicted by the availability heuristic.

Our findings are thus of critical importance for the conceptual clarification of availability and representativeness by providing empirical results that disentangle them and by defining conditions where one or the other will guide judgments.

When availability, when representativeness?

The conceptual overlap between availability and representativeness made it difficult to understand whether or when one or the other heuristic guides decisions. Previous work has emphasized the role of the accessibility of specific instances and abstract representations in determining the use of availability or representativeness (Braga, Ferreira, & Sherman, in press; Kahneman & Frederick, 2002; Sherman & Corty, 1984).

Because availability relies directly on the accessibility of instances and representativeness use involves comparing the target to a representation, the time available to process the target problem and elicit a heuristic response may determine whether one's responses are based on availability or representativeness.

When the context provided enough time, predictions were generally driven by representativeness rather than availability. In fact, although the present studies suggest that the availability of instances was computed earlier, temporal constraints increased continuation responses only to a chance level (Studies 2 and 3), and judgments were driven by availability only when representativeness could not be computed and streaks were presented subliminally (Study 3). It does seem that, when both heuristics can be computed and applied, representativeness is favored over availability. One reason why this might be occurring is the discounting of availability, because our task may provide a causal explanation for an outcome's accessibility (e.g., Schwarz et al., 1991). In accordance with such a hypothesis, in Study 1 we found that participants were aware of the most accessible outcome but did not use it directly in their predictions. However, in Study 3, when they were not aware of the sequence being presented, no external reason could account for an outcome's accessibility, and predictions relied on the availability heuristic. Apparently, if an outcome's accessibility is attributed to its previous presentation (rather than to the feeling that the cognitively available response is correct), and the outputs to be predicted are recognized as the product of a certain mechanism (e.g., random coin tossing), people may have more confidence in a response generated by a similarity-based process such as representativeness rather than in a response based on the mere accessibility of instances. Therefore, the metacognitive knowledge about the source of the accessibility of outcomes may also play a role in whether one relies on

availability or representativeness (e.g., Kubovy, 1977) and should be worth exploring in future research.

What's next?

The use of a binary decision task with a random generating mechanism was particularly good for disentangling availability from representativeness because availability predicts a streak's continuation, whereas representativeness predicts the end of a streak. Therefore, we were able to show some evidence that availability responses are computed faster than representativeness. In fact, some earlier developmental studies on probability learning using similar paradigms are also supportive of our hypothesis, as they show that young children between 3 and 4 years old predict what's next with positive recency (e.g., Derks & Paclisanu, 1967). Presumably, the absence of a representation about binary random events, and/or the inability to discount availability, impeded judgments by representativeness in the aforementioned studies, enabling a decision relying directly on the most accessible outcome.

In light of the current results, we should also consider their relevance to the hot-hand effect, the prediction of the continuation of a streak in contexts of intentional mechanisms, such as human performance (e.g., Caruso, Waytz, & Gilovich, 2010; Gilovich, Vallone, & Tversky, 1985). We suggest that, in this case, both availability and representativeness predict a streak's continuation, because responses driven by representativeness should rely on representations of intentional agents' performance that are expected to behave systematically toward a goal, and may then include more and longer streaks than representations of random unintentional events, such as coins (Caruso, et al., 2010). This and other contexts, such as probability estimation, forecasting, and risk assessment, should be worth exploring in future research in order to extend these findings to other, perhaps more applied, scenarios than predictions of

binary random events. Other classic decision tasks, initially used to exemplify the use of representativeness and availability, could also be explored to further test our arguments. Responses to representativeness-heuristic-tasks may depend more on the time available to process the heuristic problems, which has already been shown in conjunction problems (Villejoubert, 2009), than responses to availability-heuristic-tasks, which would be more insensitive to such manipulations. Such lines of research would extend results to other judgment and decision paradigms and further support our findings suggesting that availability is computed earlier than representativeness.

**Chapter V: Motivated reasoning in the prediction of sports outcomes and the belief in the “hot hand” (submitted) – Braga, J., Mata, A., Ferreira, M. B., & Sherman, S. J.**

**1. Introduction**

“...in normal conditions we will be the champions. In abnormal conditions...we will also be the champions.” José Mourinho, 2002, acting as F.C. Porto coach.

Research on judgment and decision making has always manifested a particular interest in human intuitions about random events and predictions of binary (random) outcomes (for a review, see Oskarrson, Van Boven, McClelland, & Hastie, 2009). There is a long history of studies of judgments about events produced by random mechanisms such as coin tosses, roulette wheels, or gender in biological birth processes (Ayton, Hunt, & Wright, 1989; Bar-Hillel & Wagenaar, 1991; Falk & Konold, 1997; Nickerson, 2002), as well as studies of people’s predictions in popular sports events (Alter & Oppenheimer, 2006; Bar-Eli, Avugos, & Raab, 2006; Gilovich, Vallone, & Tversky, 1985).

Intuitions about binary events have manifested themselves in two systematic beliefs: the belief in the *hot hand* – the intuition that a short run of repeated, but statistically independent, outcomes is likely to continue (e.g., Gilovich, Vallone, & Tversky, 1985); and the *gambler’s fallacy* – the intuition that a sequence of repeated outcomes is likely to stop (e.g., Tversky & Kahneman, 1971, 1974).

Researchers have tried to understand and predict when people will believe and predict that a streak will continue versus stop. Several factors, such as the time available to compute the decision (Braga, Ferreira, Sherman, & Mata, 2015), or inferences about

the characteristics of the agents generating the sequences (see Oskarsson et al., 2009), seem to influence whether one predicts a streak's continuation or alternation.

Specifically, people tend to predict that streaks generated by a nonrandom agent will continue whereas those generated by a random agent will end (Ayton & Fischer, 2004; Burns & Corpus, 2004; Tyszka, Zielonka, Dacey, & Sawicki, 2008). For instance, simply describing an ostensibly random agent in animate, goal-driven terms increases people's tendency to report that a streak will continue compared to when the random agent is described as an object (Morris, Sheldon, Ames, & Young, 2007). Similarly, Ayton and Fischer (2004) studied differences in judgments about the behavior of humans (e.g., a basketball player shooting) versus inanimate objects (e.g., a coin tossing device) and concluded that the observation of human skilled performance is a critical factor that elicits predictions of streak continuation.

More recently, Caruso, Waytz, and Epley (2010) propose that, because intentional agents behave systematically toward a goal, and because they are perceived to be skillfully guiding their action and therefore controlling the outcome (Malle & Knobe, 1997), the perceived intentionality of the generator agent should underlie the belief in the hot hand. In a series of studies, Caruso et al. (2010) manipulated the perceived intention of the generator agent, while controlling its randomness and humanness, and they found that, when agents are perceived to be intentional (unintentional), streaks are expected to continue (stop).

However, not only the generator's intentions, but also the perceiver's intentions to observe certain outcomes should be important in determining whether one predicts the streak to continue or to stop. Indeed, research has shown that the motivation to observe certain outcomes can affect human reasoning in a self-serving way, by having, for instance, a greater tendency to accept favorable information (Ditto & Lopez, 1992;

Lieberman & Chaiken, 1992), and even adopting qualitatively different reasoning strategies that conform better to one's goals (e.g., Mata, Ferreira, & Sherman, 2013). Therefore, we expect that the motivation to observe the end of a streak or its continuation will lead to wishful predictions supported by strategic beliefs in the hot hand or in the gambler's fallacy.

For example, if, in a basketball match, the team that one supports is on a scoring streak, one may be more likely to believe in the hot hand, and thus expect the streak's continuation. If, on the contrary, the rival team is on a scoring streak, one may turn to the belief that a streak cannot go on forever and must eventually come to an end (i.e., gambler's fallacy), and thus make the prediction that the undesired streak will stop

Furthermore, the desirability of a streak might trigger different attributions regarding the causes of the streak. People tend to attribute their own success to internal causes, such as ability and effort, whereas they attribute their failures to external causes such as luck or task difficulty (e.g., Campbell & Sedikides, 1999; Weary-Bradley, 1978). Likewise, in the context of a basketball game, a positive streak may be attributed to the qualities of one's favorite team, whereas failure may be attributed to external factors rather than to the qualities of the opponent team.

In two studies, we tested the hypothesis that the valence of a scoring streak (i.e., depending on whether the scoring team is the team we support or a rival team) will influence predictions of whether the streak will continue or cease, and more importantly, that these predictions will be supported by strategic beliefs in the hot hand or the gambler's fallacy, and strategic causal attributions to the team doing the scoring streak or to external factors. Thus, we predict that people make wishful predictions about the outcome of sports events by relying on strategic beliefs about how (i.e., hot

hand vs. gambler's fallacy) and why (i.e., due to internal or external causes) a streak might unfold.

## 2. Study 1

### ■ Method

Eighty students (63 men) from the University of Lisbon were contacted to participate in an online study about their beliefs about sport clubs. All participants were asked which basketball team they support, and to rate how important for their life they consider their team's performance to be, on a scale from 1 (not important at all) to 7 (extremely important).

All participants were then presented with the same segment of a basketball game between F.C. Porto and S.L. Benfica. These teams were selected because they are the most popular teams of the Portuguese Basketball league and the biggest rivals in Portugal. Therefore, supporters of these teams should be motivated not only to see their team win but also to see the other team lose. The segment displayed 12 scoring moments, 6 for each team. Critically, whereas the initial scoring moments alternated between both teams, the final 3 scoring moments belonged to F.C. Porto, forming a streak at the end of the sequence (see appendix D). Participants were then asked to predict which team was going to score next.

Afterwards, participants expressed their degree of agreement with sentences referring to the hot hand ("The Porto team seemed to be hot") and the gambler's fallacy ("No team can score that many points without conceding some"). Both measures used nine-point rating scales.

To measure how predictions could be due to internal or external causal attributions to the hot team, participants also rated on two nine-point scales how much their prediction was due to the fact that the “hot team” had more or less ability than the “cold team”, and how much their prediction was due to factors external to the “hot team”, such as luck or the referee.

We also asked participants to rate on two different 9-point scales, how confident they were on their prediction, and how important they thought the observed sequence was for their prediction. Because these two variables are not relevant for the main hypothesis they will not be reported here<sup>10</sup>.

## Results and Discussion

Based on participants’ favorite teams, 3 groups were defined such that 31 participants supported the team with the scoring streak (“hot team participants”), 31 participants supported the team that was conceding the streak (“cold team participants”), and 18 participants did not support either team (“neutral team participants”).

We tested whether there were differences in how important participants’ favorite team performance usually is across the different groups. An ANOVA revealed a main effect of streak valence condition,  $F(2,77) = 3.87, p = .025, \eta^2 = .09$ . We found that participants supporting the hot team judged their team’s performance as significantly more important for their life ( $M = 5.52, SE = .31$ ) than participants supporting the cold team ( $M = 4.29, SE = .31, F(1,77) = 7.71, p = .007, \eta^2 = .09$ ). Neutral team participants did not rate the importance of their favorite team (not presented in the sequence)

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<sup>10</sup> There were no differences between conditions on participant’s confidence in their prediction  $F(2,77) = 1.81, p = .634, (M_{hot} = 6.87, SE = .32; M_{cold} = 6.16, SE = .32; M_{neutral} = 6.00, SE = .42$ . There was also no effect of team condition on how much participant’s relied on the observed sequence to make their prediction  $F(2,77) < 1, (M_{hot} = 6.61, SE = .41; M_{cold} = 6.26, SE = .41; M_{neutral} = 6.89, SE = .54$ .

differently from either the hot team ( $M = 4.83$ ,  $SE = .40$ ,  $F(1,77) = 1.76$ ,  $p = .189$ ) or the cold team participants ( $F(1,77) = 1.11$ ,  $p = .295$ ).

### *Predictions*

Sixty-one percent of participants who did not support either of the teams predicted the continuation of the streak. More importantly, and as expected, the large majority (77%) of participants supporting the hot team predicted that the streak would continue, whereas only 25% of participants supporting the cold team did so,  $\chi^2(2, 80) = 17.12$ ,  $p < .001$ ;  $\phi = .463$ . The adjusted standardized residuals suggest that both hot team supporters ( $z = 3.4$ ,  $p < .01$ ) and cold team supporters significantly contributed to the effect ( $z = -4.0$ ,  $p < .01$ ).

### *Beliefs in the hot hand and in the gambler's fallacy*

An ANOVA revealed that the expression of belief in the hot hand varied across conditions,  $F(2,77) = 7.14$ ,  $p = .001$ ,  $\eta^2 = .16$ . As expected, the belief in the hot hand was lower for participants supporting the cold team ( $M = 4.81$ ,  $SE = 0.42$ ) than for those supporting the hot team ( $M = 6.68$ ,  $SE = 0.42$ ,  $F(1,77) = 9.89$ ,  $p = .002$ ,  $\eta^2 = .11$ ) and those supporting the neutral team ( $M = 7.06$ ,  $SE = 0.55$ ,  $F(1,77) = 10.50$ ,  $p = .002$ ,  $\eta^2 = .12$ ). No differences were found between supporters of the hot team and the neutral team ( $F < 1$ ).

Beliefs concerning the gambler's fallacy, that is, the belief that streaks tend to end, did not differ across the three team categories,  $F(2,77) < 1$ ;  $M_{hot} = 6.16$ ,  $SE = 0.46$ ;  $M_{cold} = 6.45$ ,  $SE = 0.46$ ;  $M_{neutral} = 5.78$ ,  $SE = 0.60$ ).

### *Causal attributions*

We found significant differences between conditions in how much participants attributed their predictions to the fact that the *hot* team was more skilled than the *cold* team,  $F(2,77) = 14.75, p < .001, \eta^2 = .28$ . Specifically, cold team participants attributed less responsibility to the *hot* team's higher ability ( $M = 3.55, SE = 0.37$ ) than did either participants supporting the hot team ( $M = 6.39, SE = 0.37, F(1,77) = 29.36, p < .001, \eta^2 = .28$ ) or participants supporting the neutral team ( $M = 5.17, SE = 0.49, F(1,77) = 7.01, p = .010, \eta^2 = .08$ ). Moreover, the hot team supporters attributed their prediction more to the internal attributes of the team performing the streak than did the neutral team supporters,  $F(1,77) = 3.99, p = .049, \eta^2 = .05$ . However, no differences were found between conditions for attributions to causes external to the team performing the streak,  $F(2,77) = 1.07, p = .349, (M_{hot} = 4.90, SE = 0.40; M_{cold} = 4.26, SE = 0.40; M_{neutral} = 5.11, SE = 0.52)$ .

Taken together, these results indicate that, in human performance contexts, the motivation to observe certain results leads not only to changes in predictions but also in the reasoning used to justify those predictions. Specifically, the belief in the hot hand and supporting internal attributions were affected by motivation, although the belief in that streaks tend to end (i.e., gambler's fallacy) and external attributions were not. Therefore, in such intentional contexts of human performance, predictions about streaks may depend more on how much the decision maker a) believes in the hot hand; and b) how much she attributes the outcomes to internal factors of the agent.

To further explore how the positive (for the hot team supporters) or negative valence (for the cold team supporters) of the streak affects participants' reasoning, we tested a serial mediation hypothesis according to which a streak's valence affects internal attributions to the teams performing the streak, which in turn affects the belief

that the team is hot, ultimately affecting participants' predictions<sup>11</sup> (see Hayes, 2012, on serial mediation).

A bootstrapping analysis (5000 resamples) revealed that, indeed, the effect of a streak's valence on participants' predictions is mediated by a serial path through internal attributions first and then the belief in the hot hand, 95% bias-corrected CI = [0.06, 3.37].

In Study 1, we did not directly manipulate the valence of the streak, but rather assigned participants to hot, cold, or neutral conditions according to their favorite team. Thus, it would be important to directly manipulate the valence of the streak, while holding participants' favorite team constant, further increasing experimental control.

Another aspect that deserves attention is our internal attribution measure. We asked participants to consider whether their prediction was due to the fact the *hot team* was more skilled than the *cold team*. Therefore, it is not clear whether participants' predictions are being mediated by attributions focusing on the hot team's ability, on the cold team's ability, or on the relation between both. To address this, in Study 2 we asked participants to judge the independent responsibility of each team for the predicted outcome, that is, how responsible was the streak-scoring team, and how responsible was the team who conceded the streak.

Still, Study 1 provides initial evidence that the motivation to observe a certain outcome in a binary event affects participants' predictions in a self-serving way and, more importantly, it affects their belief in the hot hand and their causal attributions.

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<sup>11</sup> Because there was not an effect of valence on the belief that streaks tend to end (i.e., gambler's fallacy as a prediction model), this factor was not included in the model.

### 3. Study 2

#### Method

One hundred-two students (65 men) from Indiana University received one course credit to participate in this laboratory study. All participants were randomly assigned to one of four conditions, where a segment with the same alternation pattern in the scoring sequence of a basketball game was presented. The segment displayed 10 initial scoring moments alternating which of the teams scored, and it ended with a streak of 4 consecutive scoring moments for one of the teams (the hot team; see appendix D). Participants could be assigned to watch a segment of a presumably personally relevant Indiana University vs. Purdue University game, where either Indiana scored the streak (positive valence condition), or Purdue scored the streak (negative valence condition); or to a neutral (presumably personally irrelevant) game (University of Arizona vs. Arizona State University) where they could either see a scoring streak from Arizona (neutral-a condition) or a scoring streak from Arizona State (neutral-b condition).

As in Study 1, participants were then asked to predict which team would score next. Afterwards, they had to express their agreement with the same sentences that were used in Study 1 to designate beliefs in the hot hand and in the gambler's fallacy, rated on nine-point scales.

Participants were also asked three more questions that will not be reported in this manuscript because we considered them irrelevant for the present paper. These items asked participants to rate on three different 9-point scales: how confident they were on their prediction<sup>12</sup>; how important they thought the observed sequence was for their prediction<sup>13</sup>; and how biased toward picking their favorite team they were<sup>14</sup>.

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<sup>12</sup> Participants confidence on their prediction was affected by streak valence condition  $F(3,98) = 2.29$ ,  $p = .084$ ,  $\eta^2 = .065$ ; such that participants in the negative valence condition seem to be more confident in

Participants rated on three nine-point scales how much their prediction was due to the “hot” team, how much it was due to the “cold” team, and how much it was due to factors external to the teams.

To ensure that participants supported the Indiana University basketball team and would therefore see a scoring streak from Indiana University (Purdue) as a positive (negative) outcome, participants were also asked which basketball team they usually support. Participants also rated how important they considered each of the team’s performance to be for their life, on scales from 1 (not important at all) to 7 (extremely important).

## Results and Discussion

When asked which basketball team they usually support, 80% of the participants across all conditions indicated Indiana University as their favorite team, and for the two conditions presenting a game involving Indiana University, 100% of the participants mentioned Indiana as their favorite team. And no differences were found across the two critical conditions in terms of how important participants considered Indiana University basketball team’s performance to be for their life, ( $M_{positive} = 5.96$ ,  $SE = 0.41$ ;  $M_{negative} = 6.88$ ,  $SE = 0.41$ ),  $F(1, 98) = 2.53$ ,  $p = .115$ ; and the same for how important was Purdue performance ( $M_{positive} = 1.52$ ,  $SE = 0.31$ ;  $M_{negative} = 1.77$ ,  $SE = 0.31$ ),  $F < 1$ .

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their prediction than participants in the other groups ( $M_{negative} = 6.74$ ,  $SE = .34$ ;  $M_{positive} = 5.74$ ,  $SE = .34$ ,  $p = .041$ ;  $M_{neutral-a} = 5.62$ ,  $SE = .35$ ,  $p = .023$ ;  $M_{neutral-b} = 5.77$ ,  $SE = .38$ ).

<sup>13</sup> The importance participants attributed to the observed sequence to make their prediction was also affected by streak valence conditions,  $F(3,98) = 3.98$ ,  $p = .010$ ,  $\eta^2 = .11$ , and suggest that participants in the neutral conditions gave more importance to that information than the others ( $M_{positive} = 5.11$ ,  $SE = .38$ ;  $M_{negative} = 5.85$ ,  $SE = .38$ ;  $M_{neutral-a} = 6.30$ ,  $SE = .39$ ;  $M_{neutral-b} = 7.00$ ,  $SE = .42$ ).

<sup>14</sup> Streak valence condition also has an effect on how biased toward picking their favorite participants thought they were,  $F(3,98) = 17.48$ ,  $p < .001$ ,  $\eta^2 = .35$ ; suggesting that participants in the negative streak condition judged themselves as more biased to pick their favorite team than the other groups ( $M_{negative} = 5.85$ ,  $SE = .45$ ;  $M_{positive} = 3.78$ ,  $SE = .45$ ;  $M_{neutral-a} = 2.12$ ,  $SE = .46$ ,  $M_{neutral-b} = 1.55$ ,  $SE = .50$  ( $M = 5.85$ ,  $SE = .45$ ).

Participants in the neutral conditions rated how important they considered the performance of the team having the streak ( $M_{neutral-a} = 2.19$ ,  $SE = 0.42$ ,  $M_{neutral-b} = 1.68$ ,  $SE = 0.45$ ;  $F < 1$ ) and the team conceding ( $M_{neutral-a} = 2.00$ ,  $SE = 0.31$ ,  $M_{neutral-b} = 1.52$ ,  $SE = 0.34$ ;  $F < 1$ ).

### *Predictions*

No differences were found between the neutral conditions in terms of predictions that the streak would continue ( $M_{neutral-a} = .50$ ,  $SE = .10$ ;  $M_{neutral-b} = .46$ ,  $SE = .08$ ),  $\chi^2(1, 48) = 0.07$ ,  $p = .790$ ;  $\phi = .038$ . Therefore, we aggregated these conditions for the following analyses. Whereas about half of the neutral condition participants predicted the streak's continuation (47.9%), very few participants in the negative valence streak condition predicted the streak's continuation (7.4%), compared to more than half of the participants in positive valence condition who predicted the streak's continuation (66.7%),  $\chi^2(2, 75) = 20.66$ ,  $p < .001$ ;  $\phi_c = .450$ . The adjusted standardized residuals showed that both the positive valence condition ( $z = 3.0$ ,  $p < .01$ ) and the negative valence condition contributed to the effect ( $z = -4.3$ ,  $p < .01$ ).

These results suggest that observing a negative streak leads participants to predict its end, whereas observing a positive valence streak leads participants to predict its continuation, thus replicating the effect of motivation on predictions found in Study 1.

### *Hot hand and gambler's fallacy*

No differences were found between neutral conditions in the degree of belief in the hot hand ( $F < 1$ ). Therefore, control conditions were aggregated in the following analyses. An ANOVA revealed that the belief in the hot hand varied across conditions,  $F(2, 99) = 4.53$ ,  $p = .013$ ,  $\eta^2 = .08$ . As expected, the belief in the hot hand was lower for participants in the negative valence condition ( $M = 5.07$ ,  $SE = .39$ ) than for those in the

positive valence condition ( $M = 6.30, SE = .38, F(1, 99) = 5.05, p = .026, \eta^2 = .05$ ) and the neutral conditions ( $M = 6.48, SE = .28, F(1, 99) = 8.54, p = .004, \eta^2 = .08$ ). No differences were found between the positive valence condition and the neutral condition,  $F < 1$ .

On the other hand, the belief that streaks tend to end (i.e., gambler's fallacy) did not differ across conditions,  $F < 1$ ;  $M_{positive} = 5.00, SE = .47$ ;  $M_{negative} = 6.04, SE = .47$ ;  $M_{neutral} = 5.42, SE = .35$ ).

These results replicate the findings from Study 1 and suggest that, whereas the belief in the hot hand may be strategically malleable in order to support wishful predictions, the belief in the gamblers' fallacy seems to be more stable and unaffected by such motivational factors.

#### *Causal attributions*

As in Study 1, we found that streak valence did not affect the extent to which participants attributed their decision to causes external to the teams,  $F < 1$  ( $M_{positive} = 4.70, SE = .42$ ;  $M_{negative} = 4.60, SE = .42$ ;  $M_{neutral} = 4.27, SE = .31$ ).

A mixed model ANOVA on participants' attributions to the "hot" and to the "cold" team as a within-subjects variable, and with streak valence as a between-subjects factor, revealed a main effect of valence,  $F(2,98) = 9.04, p < .001, \eta^2 = .15$ , such that participants in the negative streak condition made higher internal attributions than did participants in the other conditions ( $M_{positive} = 4.87, SE = .41$ ;  $M_{negative} = 6.09, SE = .41$ ;  $M_{neutral} = 3.39, SE = .31$ ). More interestingly, an interaction between which team the attribution was about (hot vs. cold) and streak valence condition was also found,  $F(2,98) = 10.15, p < .001, \eta^2 = .24$ . Planned contrasts revealed that participants in the positive valence streak condition attributed more responsibility for the predicted outcome to the "hot" (i.e., their favored) team ( $M = 5.52, SE = .53$ ) than to the "cold"

team ( $M = 4.22$ ,  $SE = .41$ ,  $F(1, 98) = 6.69$ ,  $p = .011$ ,  $\eta^2 = .06$ ), whereas participants in the negative valence streak condition attribute significantly more responsibility to the “cold” (i.e., their favored) team ( $M = 7.19$ ,  $SE = 0.41$ ) than to the “hot” team ( $M = 5.00$ ,  $SE = 0.53$ ,  $F(1,98) = 19.02$ ,  $p < .001$ ,  $\eta^2 = .16$ ). No differences between attributions to the “hot” and “cold” team were found for the neutral conditions,  $F(1, 98) = 2.19$ ,  $p = .156$ .

It thus seems that participants in the motivationally charged conditions attributed more responsibility to the ability of their favorite team, whereas participants in the neutral conditions do make different attributions depending on whether teams are having a “hot” or “cold” streak. For those participants predicting the success of their favored team, these internal causal attributions may be seen either as a factor that perpetuates a positive streak or leads to the end of a negative streak.

To further test the mechanism by which motivation affects predictions via strategic reasoning, we tested whether the difference between attributions to the “hot” vs. “cold” team would mediate the effect of motivation (streak valence) on the belief in the hot hand, and consequently on predictions.

A bootstrapping analysis (5000 resamples) revealed that the effect of a streak’s valence (positive or negative) on participants’ predictions is mediated by a serial path through the difference between attributions to the “hot” vs. “cold” teams, and then through the degree of belief in the hot hand, 95% bias-corrected CI = [0.08, 5.36]. This model thus seems to provide a better account of the effects of streak valence on participants’ predictions than a serial path through the internal attributions to the “hot” team only and the belief in the hot hand, 95% bias-corrected CI = [-0.29, 2.27], or a serial path through attributions to the cold team and the belief in the hot hand, 95% bias-corrected CI = [-0.58, 7.61], which were found to be non-significant. This supports the

conclusion that the individual contribution of each team independently is not enough to account for the effect of valence on the belief in the hot hand and subsequent predictions of the following outcome. This model also replicates the findings from Study 1, where a single measure of attribution that involved the contributions of both the hot team and the cold team (attribution of the prediction to the higher level of ability of the hot team when compared to the cold team) was found to mediate the effect of motivation on the belief in the hot hand which subsequently mediated participant's prediction.<sup>15</sup>

In sum, Study 2 replicates Study 1's finding that the motivation to observe a certain outcome affects predictions of intentional binary outcomes. It also replicates the finding that, whereas the belief in the hot hand is affected by motivation, the belief that streaks tend to end (i.e., the gambler's fallacy) is not. Moreover, Study 2 adds a more comprehensive measure of attributions to the agents involved in the sequence, and shows that participants attribute more responsibility to the team that they support than to the other team. In turn, attributions influence how much participants believe in the hot hand, which ultimately influences the prediction of the next outcome.

#### **4. General Discussion**

Extant research on predictions of binary random outcomes after a streak has identified conditions leading to predictions of a streak's continuation, the hot hand, or

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<sup>15</sup> As in Study 1, because there was not an effect of valence on the belief that streaks' tend to end (gambler's fallacy) this variable was not included in the model. However, we also ran a logistic regression on predictions for participants in the neutral conditions and found that both the belief in the hot hand ( $\beta = 1.50, p = .014$ ) and the belief in the gambler's fallacy ( $\beta = -1.44, p = .003$ ) accounted for predictions, whereas attributions to the hot ( $\beta = -0.01, p = .975$ ) or cold ( $\beta = 0.20, p = .633$ ) team were not significant predictors. This suggests that the belief in the gambler's fallacy may play a role in predictions about intentional human performance if participants are not motivated to observe streak continuation or alternation that may be explored in future research.

its end, the gambler's fallacy. Particularly important for these predictions is the perceived intentionality of the mechanism generating the sequence (Caruso et al., 2010). In the present paper, we show that the motivation to observe a certain outcome (the streak's continuation or its end) may also affect participants' attributions, beliefs, and predictions in such decision contexts. The results from two studies indicate that, in contexts with intentional agents (basketball games' scoring sequences), the valence of the streak influences how people reason about the way it will unfold. Specifically, depending on whether the observed streak is desired or undesired, people believe more or less in the hot hand in order to predict its continuation or its end.

Previous research has revealed individual differences in predictions and risk preferences in games of luck (e.g., roulette) in response to changes in streak valence (i.e., losses and gains). Players were found to behave consistently with a belief in the hot hand, believing that runs of wins were likely to continue, or in the gambler's fallacy, believing that runs of losses were about to end (Ball, 2012; Leopard, 1978; Sundali & Croson, 2006). However, those studies focused on random mechanisms, and did not explore the role of motivation in contexts where the mechanism generating the sequence is clearly intentional, which had previously been shown to promote the belief in hot hand (e.g., Caruso et al., 2010). Consistent with the idea that the belief in hot hand is a default in predictions about intentional agents is the fact that, in general, participants in the neutral conditions of our studies endorsed this belief. However, the present results show that the valence of the streak influences people's reasoning by changing how much they believe in the hot hand. In particular, when the streak is negative, observers do not endorse a belief in the hot hand. These results thus suggest that any default tendency to believe and predict according to the hot hand in contexts where the

sequence's generator is intentional can be overridden by motivation. That is, when the streak is undesired, the belief in the hot hand is reduced and streaks are expected to end.

The fact that the belief that streaks will inevitably end (i.e., the gambler's fallacy) was, however, not affected by motivation suggests that this belief is either not applicable to contexts of intentional streaks, or that it relies on somewhat more stable knowledge structures about probabilities, randomness, and regression to the mean, that may be worth exploring in future research.

Moreover, our results show that motivational variables also affect attributions of responsibility for a streak's continuation or end. Consistent with extant research on self-serving attribution (e.g., Weary-Bradley, 1978), when the streak was positive, the wishful prediction that it would continue was attributed to the qualities of the scoring team. However, when the streak was negative, the wishful prediction that it would cease was also attributed to internal factors, but this time to factors pertaining to the "cold" team (Study 2). We tested for external attribution of failure. However, most participants in the cold team did not predict failure, but rather success, in predicting that the negative streak would stop. Therefore, they too made internal attributions to back up their predictions. One critical factor determining whether or not we might observe defensive external attribution is that the attributions that we asked for were about the next/predicted outcome, and not about the past/observed streak. Cold team supporters were shown to make internal attributions to support their predictions of future success, but they would probably make external attributions to justify the past failure that the observed negative streak represents.

Mediational analyses helped to shed light on the reasoning path underlying motivated predictions of how desired or undesired streaks might unfold: Motivation (i.e., whether a streak is desired or not) influences causal attributions, which in turn

influence whether or not one believes in the hot hand, ultimately influencing the prediction of whether a streak will continue or stop. In sum, this work provides a better understanding of the mechanisms underlying predictions of intentionally generated events after a streak, by showing that the motivation to observe a certain outcome affects people's attributions, beliefs, and predictions in a self-serving way.

## **Chapter V: General Discussion**

### **1. Summary**

The goal of the present dissertation was to conceptually and empirically disentangle the representativeness and the availability heuristics, thus clarifying conditions for the use one heuristic or the other. Four empirical chapters explored the impact of the level of abstraction; the computational speed; and directional motivation on the computation of these heuristics. The impact of these variables on the representativeness and availability heuristics not only provides a better understanding of the mechanism of these heuristics as they also suggest conditions that determine its use.

Chapter II argues that the cognitive processes underlying the representativeness heuristic are generally more abstract than the processes underlying availability. Grounded on the construal level theory (e.g., Trope & Liberman, 2000) the first empirical paper of this dissertation generally suggests that representativeness based judgments are facilitated under conditions that induced a focus on more abstract information and processes, whereas availability judgments seemed to be facilitate when concrete mindsets are induced.

Chapters III and IV propose that when both representativeness and availability can be applied, representativeness heuristic should take longer to be computed than the availability heuristic because the processes underlying the former may be cognitively more complex than the later. A binary prediction task about random events tested this hypothesis. It was argued that in that paradigm representativeness predicts the end of streaks but availability predicts streaks' continuations. Time pressure manipulations increased "continuation responses", and subliminal presentations reversed the typical gambler's fallacy effect. The representativeness heuristic thus seems to depend on the

attentional and temporal computational conditions, whereas availability is less sensitive to such constraints.

Chapter V argues that directional motivation, that is, the motivation to observe one outcome over another, may impact the accessibility knowledge structures used to compute the heuristics (e.g., Kunda, 1990). In predictions of binary events, directional motivation was found to increase predictions of the most desired outcome. More importantly this effect was found to be mediated by participants' representations about the event. That is, motivation affected how much responsibility participants attribute to the agents of the sequence, thus affecting whether streaks are expected to continue or not, which in turn influence participants' predictions.

The present chapter will discuss the individual contribution of each empirical chapter and their combined contribution for the understanding of the mechanisms underlying the representativeness and the availability heuristics. It will further discuss the consequences of the present findings for general models of judgment and decision making, and for other theoretical frameworks, such as the construal level theory.

## **2. Discussion of the effects of construal level on heuristic reasoning**

The construal level theory has shown how differences in psychological distance or approaching a problem with a more abstract or concrete mindset can change the process and outcome of our judgments and decisions (Trope & Liberman, 2010).

Previous theoretical work has emphasized that one of the main differences between representativeness and availability is that representativeness heuristic depends on the accessibility of abstract information (e.g., a categorical representation), whereas availability depends on the accessibility of more concrete information (e.g., recalled

exemplars) (e.g., Kahneman & Frederick, 2002; Sherman & Corty, 1984, Tversky & Kahneman, 1973, study 7). Braga et al., (2015) provided empirical evidence for this conceptual difference by suggesting that high levels of construal increase specific judgment biases stemming from representativeness; and low levels of construal leads to more judgments based on the availability heuristic. Even though these judgment problems do not provide pure measures of the processes underlying representativeness and availability, the findings are congruent with the proposed distinction between these heuristics. The mediational role of representativeness could be more directly tested if, for instance, the extent with which the description of the target is stereotypic of an engineer was manipulated. More stereotypical descriptions would be expected to receive more weight in high levels of construal when compared to low levels.

Yet, these studies (Braga et al., 2015) contributed to clarify the conditions under which representativeness and availability are used, which is of critical importance in establishing the explanatory value of these heuristics and in addressing previous criticisms (e.g., Anderson, 1990; Gigerenzer, 1991). As argued before, one problem with the heuristic and biases approach was that the same judgments and biases could sometimes be explained by different heuristics. Decision problems involving individuating information, such as the lawyers and engineers base-rate problem, are particularly good examples of this criticism. Some authors have considered the base rates in this problem to represent rather remote and abstract information (Gigerenzer, Hell, & Blank, 1988; Nisbett & Borgida, 1975; Nisbett & Ross, 1980), making the availability heuristic a plausible alternative account for judgments that neglect the base-rates and rely on the stereotypical description of the target. The findings from our studies speak against such hypothesis, as high levels of construal increased base-rate

neglect when compared to low levels of construal. The data rather supports the depiction of base-rates information as more concrete than the stereotypical description of the target (Kahneman & Tversky, 1972).

### ■ **High level and Low level information.**

It is important to acknowledge that whether base-rates, or any other information, will be overvalued by high or low levels of construal is a relative problem. That is, base-rates are specific and concrete numbers; however they also represent general population statistics and not specific individuals. Thus, whether base-rates are perceived as high or low level may depend on the level of abstraction of the alternative information available. This would explain why some previous studies found that high levels of construal promoted reliance on information similar to base-rates (Burgoon, Henderson, & Walker, 2013; Henderson et al., 2006; Ledgerwood, Wakslak, & Wang, 2010).

For instance, Ledgerwood, and colleagues (2010) asked participants to choose between two products. One product was favored by aggregate information, such as average reviews of the product. The other product was favored by individualized information, such as a particular opinion. High construal conditions (vs. low construal), induced by temporal distance, increased the relative weight placed on aggregate information compared to the weight placed on individualized information. In this study, Ledgerwood et al. (2010) pitted population information (i.e., base rates) versus information about one specific person, and high-level construal increased the likelihood of using the more abstract and less concrete information, the base rates. In Henderson et al (2006), the two possible bases for judgment were global information from outcomes over a long period of time (i.e., base-rate information) versus a local, recent and specific

outcome. Once more, high-level construal favored the use of base rates (i.e., the more abstract information).

On the contrary, in Braga et al. (2015), the alternative to base-rate information was rather abstract. Participants were presented with base-rate information and a stereotypic description of an individual. This stereotypical information was more abstract than base-rates. Therefore, a judgment of similarity between the description and the prototypical lawyer (or engineer) would be more likely for high levels of construal, thus supporting the representativeness account of the base-rate neglect.

It is likely that information lies in an abstraction continuum and whether it pertains to high or low level of construing the reality may depend on whether the standard of comparison is positioned in a more or less abstract point of the continuum.

It is important to understand that whichever basis for judgment, the base rates or the alternative (e.g., the target description), is more abstract, the greater weight will be given to that basis under a high construal level<sup>16</sup>. This conclusion is also essential to understand the relation between levels of construal and intuitive decision processes. The studies under discussion suggest that manipulations in the level of construal is a way to discriminate between representativeness and availability accounts of base-rate neglect and to disentangle the cognitive processes underlying these two heuristics. Yet, they also contribute for the understanding of how distance and the level of abstraction affect intuition and the use of heuristic mechanisms.

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<sup>16</sup> However, it is also possible that differences in time pressure, accuracy motivation, or level of cognitive fluency could account for the different results found across the various studies. For example, manipulating the interpretation of fluency has been shown to reverse the effect of construal level on evaluative judgments (Tsai & Thomas, 2011). Future research should investigate the role of these factors in moderating the effects of construal level on the use of judgment heuristics.

## ■ **Construal level theory and heuristic reasoning.**

Previous research has failed to find differences in motivation or accuracy due to changes in the level of construal (e.g., Smith & Trope, 2006; Wakslak et al., 2006) that could affect reliance on heuristic processes. The present findings suggest that, more than having a general effect on the use of heuristics, high and low levels of construal may affect the use of specific heuristics in agreement with the different types of information and cognitive processes upon which these heuristics rely. This strongly suggests that both high and low levels of construal can promote intuitive heuristic processes of judgment and decision making, and that the cognitive processes grounded in high or low levels of construal are not more or less rational or proscriptively better or worse. Depending on the particular problem and information available, both high-level and low-level construals can either increase or reduce different forms of heuristic judgments. If the relevant heuristic is representativeness (as in the Linda problem), a high level of construal will increase the bias (i.e., greater conjunction fallacy) whereas a low level of construal will decrease the bias (i.e., reduced conjunction fallacy). On the other hand, when the relevant heuristic is availability (as in, the famous names problem), a high level of construal decreases the bias (i.e., fewer heuristic-based errors in frequency judgments) whereas a low level of construal will increase the bias (i.e., more errors in frequency judgments).

This conclusion is nonetheless congruent with some previous studies demonstrating that both high-level and low-level construal can promote systematic or elaborative information processing under the right conditions (see Fujita, Eyal, Chaiken, Trope, & Liberman, 2008, Study 3) and helps to understand seemingly incongruent findings showing sometimes more controlled processes under high levels of construal (Fujita et al., 2006) but other times more controlled processes for low levels of construal

(Schmeichel, Vohs & Duke, 2010). In sum, the construal level theory is inherently comparative.

First, whether high or low levels of construal favor the use of certain information depends on the relative level of abstraction of the information available. As aforementioned, if base-rate information is compared to a stereotypical description, the use of base-rates will be reduced for high levels, but if base-rates are compared to a single exemplar, then high levels should increase its use. Second, whether a specific heuristic or cognitive process will be used for the decision, should depend not only on whether the information used by that process becomes more or less accessible for certain level of construal (for instance, in the previous example, high levels of construal facilitate reliance on stereotypes thus facilitating representativeness based judgments), but it should also depend on the level of abstraction of the cognitive processes available to solve the problem. In Braga et al., (2015, Study 2) many participants in the low level condition seemed to be using representativeness heuristic (base-rates were neglected in their judgments), although in a smaller number than participants in the high level condition. However, high level condition participants were faster in their decision to neglect the base-rates than participants in the low level condition who made that same decision. Perhaps, the lawyer and engineer task does not provide any alternative heuristic decision process that would be favored by low levels of construal, therefore, for this participants low levels of construal may have just reduced the access to stereotypical abstract information and hinder the perception of similarity between the target and that representation, making these participants slower to compute the representativeness heuristic. Alternatively, if the decision problem would also suit other, more concrete, decision heuristic, besides representativeness, low levels of construal would facilitate reliance on that process. In the same vein, if the task would suit other

more abstract cognitive process perhaps high levels of construal would favor such process rather than representativeness.

### ■ Summary and future directions

Manipulating the impact of construal level seems to be a way to discriminate between representativeness and availability. Availability heuristic relies directly on the accessibility of instances. This is a rather concrete process that seems more likely to occur when the target is psychologically close or construed upon its low level features. On the other hand, representativeness heuristic is a two stage process that relies on the substitution of an event by a categorical representation followed by the computation of the similarity between the target and the prototype. Reliance on abstract categorical information and judgments focused on similarities between a target and a category are rather abstract processes that have been shown to be facilitated for high levels of construal. Therefore, judgments relying on the representativeness heuristic were found to be more likely when the target problem is construed at a higher level.

It is important to highlight, however, that the studies reported on Braga et al (2015) have only shown how the level of construal affects the use of representativeness and availability in tasks designed to elicit the use of these specific heuristic mechanism. Despite the aforementioned controversy about the process underlying the base-rate neglect (representativeness or availability), the decision tasks used to test the effect of construal level on the use of these heuristics were particularly suited for the use of representativeness (conjunction problem and base-rates problem) or availability (famous names problem).

As argued, whether certain information and process will be favored by high or low levels of construal may depend on the alternatives available. Therefore, a decision

context where representativeness and availability would compete for the response would provide an ideal setting to empirically disentangle these heuristics. That is, a decision task where both heuristics could be used but where each heuristic would lead to clearly different outcomes would be particularly important to pit representativeness against availability and test whether in low levels of construal availability heuristic would prevail over representativeness; but that under high levels of construal representativeness would overcome availability. Such a paradigm would contribute for a better understanding of the conditions promoting the use of one or the other heuristic and help clarifying the relation between them.

The reported findings contribute not only for the understanding of the processes underlying representativeness and availability but also to the comprehension of the construal level theory regarding the use of reasoning heuristics and intuition, by suggesting that whether high or low levels of construal facilitate the use of heuristic mechanisms should depend on the cognitive processes underlying each specific heuristic. Therefore, construal level theory and psychological distance may also help to understand the conditions under which other heuristic processes become more easy or difficult to use. The first natural extension of these findings should be a generalization of the findings to other prototype heuristics and extensional attributes. Prototype heuristics include representativeness and rely on the substitution of an event by a categorical representation (prototype), but the similarity between the target and the prototype (representativeness) is not necessarily the heuristic attribute computed.

The target attributes to which prototype heuristics are applied are extensional in the sense they refer to an aggregated property of a set for which an extension is specified, for instance the probability of category membership (the probability that a set of 30 lawyers includes the target) or the value of a set of experiences (the overall

unpleasantness of a set of moments of hearing a neighbor's car alarm) or goods (the personal dollar value of saving a certain number of birds from drowning in oil ponds). Normative judgments of extensional attributes are governed by a principle of conditional adding, where each element of the set adds to the overall judgment an amount that depends on the elements already included. Therefore, in the lawyer and engineer problem, the probability of being a member of the category of lawyers and engineers should take into account the size of the category that is the base-rates. In this case, by substituting the category set by a prototype, representativeness heuristic disregards base-rates because the prototype does not provide any information about the size of the category.

The same seems to apply to other extensional attributes such as scope (e.g., Desvougues et al., 1993, Kahneman, 1986; McFadden & Leonard, 1993, see Frederick & Fischhoff, 1998 for an overview) and duration (e.g., Ariely, 1998; Fredrickson & Kahneman, 1993; Redelmeier & Kahneman, 1996; Schreiber & Kahneman, 2000) to which people is often insensitive because they replace the target by an abstract representation that ignores these extensional properties. As an example of scope neglect, the willingness to pay to save migrating birds from drowning in uncovered oil ponds was insensitive to the number of birds said to die of that cause (Desvougues et al., 1993). According to prototype heuristics this results from substituting the death of numerous birds by a prototypical representation of the event, perhaps the image of a bird dying soaked in oil, which disregards the number of birds posit by the problem. The intensity of the affective response (another heuristic attribute) to such prototype is then used to map the willingness to pay.

In the same way, the global evaluation of a temporally extended experience, such as the set of moments of an unpleasant experience was found to be insensitive (not

correlated) to the duration of the experience. Global evaluations are rather predicted by a simple average of the peak affect recorded during the experience and the end affect reported as the experience was about to end (e.g., Frederickson & Kahneman, 1993). Again, according to prototype heuristics, duration neglect occurs because the episode is represented by a prototypical moment that neglects the duration of the experience, and then, the affective value attached to the representative moment is substituted for the extensional target attribute of global evaluation.

As mentioned before, increased psychological distance and high levels of construal were found to facilitate judgments based on categorical abstract information (e.g., Fujita et al., 2006; Liberman et al., 2002; McCrea et al., 2012). Therefore, high levels of construal, when compared to low levels of construal, should increase scope neglect in willingness to pay tasks, and duration neglect in the evaluation of experiences. For instance, the willingness to pay for a humanitarian cause taking action in a distance place may be less sensitive to how many lives will be saved than if the action is taking place close from you. As distance increases, the overall value of helping a humanitarian cause should be more likely to be substituted by a representation that ignores extensional properties of the target.

These are promising avenues for future research that could contribute for the understanding of the conditions promoting judgments based on prototype heuristics, develop the explanatory power of the construal level theory, and have a potential effect in applied contexts, since psychological distance may play a role on the neglect of such extensional attributes when a prototype of the event is available. Prototype heuristics are a generalization of the representativeness heuristic and a natural addition to the present work that would take the present findings beyond availability and representativeness heuristics.

### **3. Discussion of the effects of time constraints in the “what’s next” paradigm**

The conceptual overlap between availability and representativeness made it difficult to understand whether or when one or the other heuristic guides decisions. This paper proposes that because availability judgments are based on the accessibility of instances whereas judgments based on the representativeness heuristic presupposes a two stage process of retrieving a prototype of the event and its comparison to the target, availability should be faster to compute than representativeness. The ideal setting to test this hypothesis and pit representativeness against availability would be a decision task where both heuristics could be applied yet yielding opposite responses. Predictions of binary random events such as coin tosses, seemed to be a promising decision context for the test of this hypothesis because after a streak predictions based on representativeness will lead to the end of the streak, whereas predictions relying on the availability will lead to streak’s continuation.

In previous studies using this paradigm, participants showed a tendency to predict according to representativeness and expect the end of streaks. In the present studies, however, when time constraints were imposed there was a reduction of these alternation responses expected by representativeness heuristic, and predictions of streak continuation became more likely. If predictions of streaks alternation reflect the use of representativeness heuristic, this result suggests that representativeness heuristic is sensitive to time constraints. On the other hand, continuation responses predicted by availability heuristic were increased under time-pressure and dominate participants’ predictions when streaks were presented subliminally and representativeness could not be computed.

## ■ Availability vs. Representativeness and complementary accounts

Although promising, these results may also reflect other cognitive processes or effects besides shifts between representativeness and availability.

First, it is important to acknowledge that because this is a binary decision task, responses in one direction may simply reflect avoidance of the other response. Thus, if availability heuristic would indeed predict streak's continuation as it seems to be the case, alternation responses associated to the gambler's fallacy could simply reflect the discounting of availability. As argued before, the effects of availability can be discounted when there is a plausible cause for the increase in instances accessibility other than the feeling that the cognitively available response is the most likely to occur. This may to be the case in the "what's next" paradigm. In the first study, participants were found to be aware that the outcome of the streak is more accessible even though their predictions go in the opposite direction. The discounting of these effects of accessibility is likely to be resource dependent and sensitive to time constraints, which could explain why under time-pressure participants are less capable of discounting the availability. Moreover, when the sequences were presented outside of awareness, no external reason could account for an outcome's accessibility, and predictions relied on the availability heuristic.

In the same way, these results can also reflect more general context effects of assimilation and contrast. *Assimilation* refers to a positive relation between the value people place on a target stimulus and the value they place on the contextual stimuli that accompany the target. *Contrast* refers to a negative relation between these two values (cf. Sherman, Ahlm, Berman, & Lynn, 1978). When ambiguous stimuli are rated in the context of moderately extreme stimuli, assimilation may occur. As an example, an animal of ambiguous size (e.g., a fictional animal) will be rated as relatively large by

subjects who have previously rated the size of a horse but will be rated as relatively small by subjects who have previously rated the size of a whale (Herr, Sherman, & Fazio, 1983). However, it was also shown that when participants are aware of the priming they can discount the context, and *contrast* occurs (e.g., Lombardi, Higgins & Bargh, 1987; Martin, 1986; Newman & Uleman, 1990; Strack, Schwarz, Bless, Kubler, & Wanke, 1989). Moreover, these effects of assimilation and contrast seem to depend on the cognitive effort (Martin, Seta & Crelia, 1990). When participants are distracted or have low motivation they are more likely to show assimilation than contrast, thus suggesting that the processes involved in *contrast* demand more cognitive effort than do the processes involved in *assimilation* (Martin et al., 1990). These same phenomena may be present in the studies under discussion. When participants are aware of the target streak they are more likely to contrast the primed outcome than when they are under time-pressure or the stimuli is presented outside of awareness.

These additional explanations do not put into question the use of representativeness heuristic as an explanation for the gambler's fallacy in this paradigm. It is unlikely that under optimal cognitive and attentional conditions people's predictions would not reflect their conceptions of randomness. That is, the expectation that sequences of random binary events should have very few streaks and many alternations. In fact, if we consider that in the first study of Chapter III participants were actually faster to complete direct judgments of representativeness (*how random looking is the sequence*) after making a prediction than after judging the most accessible outcome in their minds (although the difference did not reach statistical significance) then the process underlying participant's prediction seems to involve, to some extent, the computation of the representativeness heuristic, and not simply the discounting of availability. Other effects associated to lay concepts of randomness, such as memory

biases for random events, for instance recalling a sequence generated by a random mechanism as having fewer and smaller streaks than it actually has (Olivola & Oppenheimer, 2008), can also be easily accounted by representativeness but not by discounting of availability or assimilation/contrast effects. Therefore, rather than competing explanations, assimilation and contrast, and discounting of availability, may be seen as complementary accounts for the interpretation of the present findings. In fact, judgments based on availability as a direct effect of instances accessibility can be seen as assimilation effects. However, *assimilation* and *contrast* simply indicate the direction of context effects, and not the processes underlying them. Nonetheless, it is, plausible that people will indeed discount the availability of the outcome of the streak in this paradigm. However, it is likely they will then compute the representativeness heuristic in order to predict the next outcome.

### ■ **Disentangling Availability from. Representativeness**

When both heuristics can be computed and applied, and the decision context provides an external causal explanation for an outcome's accessibility, representativeness seems to be favored over availability. In such conditions, it may be that people have more confidence in a response generated by a similarity-based process such as representativeness rather than in a response based on the mere accessibility of instances. Therefore, the metacognitive knowledge about the judgment processes (for instance, metacognitions about the source of the accessibility of outcomes) may also play a role in whether one relies on availability or representativeness (e.g., Kubovy, 1977) and should be worth of future research.

The results from the presented studies are in accordance with such hypothesis, however, it would be important to test whether there are differences in the

metacognitions regarding representativeness and availability in yet another decision task (or a manipulation of the “what’s next” paradigm) that would include a subtle increase in instances accessibility (for instance, subliminally priming these instances) while allowing the computation of representativeness heuristic. Take for example a task similar to the base-rates lawyer and engineer problem, where participants have to decide whether a target is more likely to be a member of group a) or group b). The target may then be described as prototypical of group a); but instances accessibility of group b) can be made subtly more accessible by subliminal priming. Representativeness based decisions would judge the target as more likely to be a member of group a); whereas an availability based judgment would judge the target as more likely to be a member of group b). Whether one or the other heuristic would dominate judgments under optimal conditions when instances accessibility is subtly increased, would test for differences between these two heuristics in the metacognitive feelings of confidence in the judgments.

However, the confidence associated to a decision process may also depend on contextual variables or proprieties of the task. Therefore, these ideas may also be explored under the lens of Higgins’ Synapse Model (Higgins, 1989) that relates the accessibility of a construct with its applicability to a certain context. According to the model, knowledge constructs are typically activated as a function of their applicability or fit (based on the similarity between the attributes of the construct and the task). Therefore, the activation of a construct reflects, in most cases, its relevance in a given context (Sedikides & Skowronski, 1991). However, applicability does not determine a construct's activation and use directly. Even if a construct's applicability is low, it can become available for use if it has already been activated in a prior context and perceivers are unaware of the source of activation of the extraneous material,

particularly if there are no alternative constructs with greater applicability. For example, this may be the case when the information available about the target is sparse, vague, or non-diagnostic (Higgins & Brendl, 1995). On the other hand, cognitive busyness, for instance, may decrease the likelihood of activating a tool even if it fits the task and has a high applicability (e.g., Gilbert & Hixon, 1991).

According to this framework, the present context of binary predictions of random events after observing a sequence may be seen as having a better fit to the representativeness heuristic than to the availability heuristic. Constructs regarding random binary events should be activated in this context and compared to the target sequence. Thus, although instances accessibility is increased, perceivers are likely aware of its activation, making it less applicable to the task. However, even if availability heuristic applicability is low when compared to representativeness, when the target sequence is perceived under time-pressure, representativeness cannot be applied and judgments by availability may be used, particularly, when perceivers are unaware of source of the increased accessibility of instances (for instance when instances are subliminally primed). This account would thus explain why representativeness takes precedent over availability in the “what’s next” paradigm in terms of the applicability of the heuristic mechanism to the task and highlights the importance of understanding the relation between the cognitive processes and task characteristics that has also been highlighted by other authors (e.g., Hammond, 1988).

### **■ Is Representativeness always slower than Availability?**

It has been argued that in contexts where both heuristics could be easily used, such as in the predictions of coin tosses after a streak, judgments of representativeness

were found to depend more on the time available to compute the response than availability.

However, the hypothesized difference in efficiency between representativeness and availability may not be independent of the specific decision context where it occurs because the application these heuristics should depend on the accessibility of the heuristic attributes (Kahneman & Frederick, 2002; 2005). Therefore, there may be situations where the instances, upon which the availability heuristic depend, are less accessible, making a judgment based on availability difficult to compute comparing to a judgment by representativeness. To illustrate this situation, one may have an accessible stereotype to apply in order to predict a target's behavior. For instance, using the stereotype of gypsy (a group that is represented as "stealers") to predict whether a person who resembles a gypsy is going to steal, or not, another person. In this case, based on the representativeness heuristic it is likely that the prediction will be that the target is going to steal the other person because he is representative of a gypsy. It may also be that the person making the prediction does not have any accessible instances regarding the target-person or the gypsy group, either congruent or incongruent with the stereotype. In that case it would be difficult to make a judgment by availability because there is not a difference of accessibility between the two classes of events (say stealing behaviors or non-stealing behaviors; death by bee stings or snake bites; heads or tails)<sup>17</sup>.

Other contextual or task conditions could presumably facilitate and make judgments based on representativeness faster to compute when compared to judgments based on the availability heuristic. For example, the studies from Chapter II show that

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<sup>17</sup> Note that low accessibility of instances of an outcome may lead to infer that the outcome has a low probability, and that would still be a judgment by availability. However, this illustration denotes the case when two classes of events are almost equally accessible. On the limit, if instances accessibility for both response options are identical, availability would not provide a response.

the high or low level of construal may facilitate the use of representativeness or availability. Presumably, in these studies abstract mindsets facilitated the use of representativeness and made it difficult to retrieve specific instances that trigger availability.

Finally, it is worth noting that there is plenty of room for discussion, regarding the relation between representativeness and availability. For instance, even if a judgment by representativeness takes more time to be completed than a judgment by availability, this does not clarify whether the activation of these heuristics occur sequentially or in parallel, which may also contribute to understand the previous issue. One may also speculate that in many cases the representativeness heuristic is likely to be computed only after the initial cognitive processing that is also used to generate judgments by availability heuristic were compute. It was argue that availability judgments can be computed based on the mere accessibility resulting from the direct processing of the stimuli (for instance, the processing a streak of heads will increase the accessibility of “heads” and a judgment by availability can be computed). As such, the computation of the representativeness heuristic would always imply that the mere stimuli processing that may allow the computation of the availability already occurred.

### ■ **What’s next? Future directions**

The interpretation of the results under discussion seems to be somewhat dependent of the “what’s next” paradigm. However, distinguishing between two heuristic processes to make judgments and predictions, certainly allow us to go beyond predictions of coin tosses. In fact, generally the studies under discussion ask whether it is easier to make predictions based on the most easily accessible information and expect the future to be a continuation of the recent past (in the working memory); or if it is

easier to make predictions based on the similarity with an abstract representation of a more complex pattern and expect the future to complete that pattern (stored in long term memory).

Therefore, other judgment situations with the potential to extend the present studies to more natural and socially embedded contexts should assure that predictions can be based on abstract representations that expect systematic repetitions of some pattern stored in long term memory. However, they should also allow judgments and predictions to be based on, or integrate, other, more concrete and salient information about the recent past, accessible to the working memory.

Indeed, many general causal beliefs imply such expectations of complex patterns between causes and outcomes, but are nonetheless subject to new and accessible information regarding the relation between the putative cause and the outcome. For instance, one general and shared causal belief is the belief in a just world (for an overview see Lerner & Montada, 1998). The belief in a just world implies an expectation that bad things will happen to bad people, whereas good things will happen to good people. Thus, being a good (bad) person and doing good (bad) deeds will cause that person to have positive (negative) life events. Consequently, if some person is described as a doing bad deeds, she is expected to live negative life events, particularly if she just had a streak of positive events in her life. That is, the valence of life events should be representative of immanent justice. Therefore, a judgment based on representativeness will predict that future life events will restore justice. A streak of positive events in the life of a bad person will then increase the expectation of a negative event in that person's life. In such situation, time constraints during the activation of these beliefs about patterns of life events, may lead to simply predict the continuation of the recent and accessible past positive events. In the same way, other

representations of complex patterns such as business cycles or weather patterns, provide natural contexts of prediction and could also take this research one step further as to show its applicability and generalization of the results.

Other natural research directions to further extend the present findings would include time-pressure manipulations in tasks where only availability or representativeness is expected to be expressed. For instance, the famous-names problem and the lawyer and engineer base-rate problem, used in the previous empirical work are likely candidates. Congruent with this idea and the reported findings, previous research has already shown that representativeness based responses in the conjunction problem were decreased due to time-pressure manipulations (Villejoubert, 2009). On the other hand, time-pressure seem to increase judgments attributed to availability (e.g., Finucane et al., 2000). It would also be interesting to extend the idea that the computation of representativeness is sensitive to time constraints to prototype heuristics that also conceptualize a two-step attribute substitution process. For instance, effects of scope neglect in willingness to pay tasks, and duration neglect in the evaluation of experiences may potentially be reduced by time constraints.

#### **4. Discussion of the effects of motivation on representativeness heuristic**

The fourth empirical paper presented in this dissertation aims at exploring the effect of motivated reasoning on the representativeness heuristic. This work used a paradigm of binary predictions regarding the next team to score in a basketball game. According to the representativeness heuristic, after observing a streak performed by one of the teams, people will compare that sequence of outcomes to a prototype of a scoring sequence of basketball game. Whether people represent the event of a basketball game, as implying a process where streaks are likely or unlikely will determine, respectively,

predictions of streaks continuation or its end. Caruso et al. (2010) suggested that representing the event in such terms depend on how much the outcome of the next scoring moment is attributed to the intention and responsibility of the agent performing the streak. Accordingly, high perceived intentionality and responsibility will then lead to predict streak's continuation whereas low perceived intentionality and responsibility will lead to predict streak's end (Caruso et al., 2010).

The fourth empirical paper of this dissertation tested whether the motivation to observe one of the teams succeed would affect the mechanisms by which people predict the next outcome of a basketball game. That is, whether motivation affects how people represent the event and makes causal attributions, which affects the belief that streaks will tend to continue or to end, and consequently impacts the prediction of the next scoring moment of the game in a self-serving way.

The findings are generally supportive of this hypothesis. First participants predicted that their favorite team would be the next one to succeed, which implied to predict the end of a negative valence streak (streak of points against participant's favorite team), but to predict the continuation of a positive valence streak (streak of points scored by the favorite team). However, and most importantly, these predictions seem to depend on how streak's valence changed participant's reasoning and the representation of the event.

The results suggested that people attribute more responsibility to the team they want to see succeed regardless of whether the team had a streak of scoring moments or a streak of conceding points. In other words, participants observe a positive streak attribute more responsibility to the team who is scoring repeatedly than to the other team, whereas participants observing a negative streak attribute more responsibility to the losing or cold team than to the other team. Directional motivation also affected

how much people believe that the team having a scoring streak was “hot” and that streaks tend to continue. Such that participants who observed a positive streak believed that streaks tend to continue to a larger extent than participants who observed a negative streak.

The effect of streak valence on participants’ predictions was thus mediated by the effect of valence on these representations of the event. Specifically, directional motivation seems to have an effect on how much participants attribute the next outcome of the game to the ability of the teams playing the game (a difference between the responsibility attributed to the team having a positive streak and the team having a negative streak). These attributions then affect how much participants believe the scoring team is “hot” and that streaks tend to continue, which ultimately leads participants to predict the desired outcome.

In sum, motivated reasoning seems to have an effect on the mechanisms underlying judgments based on the representativeness heuristic. Specifically, one’s own desires and goals seem to affect the representation of the event that is compared to the target in order to compute the representativeness heuristic. In this binary prediction task, the target event is represented as if the agents producing the streak are more or less intentional, thus leading to expect streaks to, respectively continue or to cease. The presented studies suggest that the output of the representativeness heuristic is vulnerable to one’s goals and motivations because the representation of the processes or event used to compute representativeness is malleable and depends on one’s goals.

### ■ **Competing Intentionality**

Previous research suggested that the perceived intentionality of the event determines whether the event is expected to continue or end streaks of binary outcomes

(Caruso et al., 2010). In the studies under discussion however, we did not manipulate whether the mechanism was perceived as intentional or not. Instead, the valence of the observed streak affected the attributions of responsibility to the teams generating the sequence. These attributions of responsibility have been treated as a proxy of intentionality. However, it is worth noting, that the event scenario from the present studies should always be perceived as an intentional one, in the sense that it presents two teams that are looking forward to score the next basket.

Therefore, these findings extend the work of Caruso and colleagues not only because they show that one's own goals and interests determine whether streaks are predicted to continue or to end, but also because they explore an interaction between two intentional agents. One that seeks to continue the streak and the other that wants to end it. This is important as it is the difference between the attributions of responsibility to each team (the "hot" and the "cold" teams) that mediates the effect of directional motivation on participant's predictions, and not only participants' single attributions to one of the teams (either the one having a positive streak or the one having a negative streak).

It is thus important to consider that the effect of intentionality on predictions of binary outcomes may depend on the interaction between the agents of the streak. Because both teams are intentionally trying to score, the simple perception of intentionality may not be enough to determine whether the event tends to continue or to end streaks. Therefore, whether one agent is perceived as more responsible than the other may be seen as a more specific variable that extends and disambiguates the role of perceived intentionality as a determinant of people's predictions, particularly when there are two competing intentional agents.

Finally, even though attributions to both teams seem to be important to understand how motivation affects predictions in contexts where two intentional agents compete, it is noteworthy, that participants are essentially attributing more responsibility to their favorite team. They expect their favorite team to be the next one to score and attribute that prediction to their favorite team's ability. This tendency is not surprising as predictions of success (e.g., that one's favorite team is the next to score), are typically attributed the self, in this case, to one's favorite team (e.g., Weary-Bradley, 1978).

### ■ **Motivated Reasoning and heuristic mechanisms**

The results from these studies suggest that motivated reasoning may determine the outcome of a heuristic judgment. These studies suggest that the computation of the representativeness heuristic seems to rely on the representation of the event that will render the most favourable outcome.

An alternative explanation is that motivation increases the effort and may lead participants to engage in a more deliberate processing which could lead to the inhibition of judgments by representativeness and consequently decrease a potential tendency to predict in accordance to the hot hand effect. However, it may be worth noting that, in these studies, there is not a clear hot hand effect for participants in the control condition, when judgements were not driven by any directional goals. Although participants in the neutral conditions exhibit a high belief in the hot hand, this belief is not expressed in their predictions. As discussed before, in this paradigm participants observed two intentional agents, one that intended to end the streak and another that intended to continue the streak. Because these representations of intentionality and responsibility should be used to compute the representativeness heuristic, it is not clear that a

judgment by representativeness would lead to the hot-hand effect as default response. In that case, predicting streak's end cannot be argued to result from engaging in a more deliberate reasoning process that suppresses a response based on the representativeness heuristic; because the representativeness heuristic does not necessarily predicts a hot hand effect when both agents of the sequence are perceived as intentionally trying to achieve opposite outcomes.

According to the present hypothesis, previous research has suggested that directional goals may increase the accessibility of self-serving information by biasing the memory processes and not necessarily by increasing effort (e.g., Kunda, 1990). Furthermore, goals are associated to means of achieving them, and the activation of a goal likely activates the means for attaining it (e.g., Shah & Kruglanski, 2002). Therefore, the means to conclude that streaks are going to continue, or to end, are knowledge structures about causal attributions and beliefs regarding this binary event. This knowledge justifying why streaks should continue, or justifying why streaks should end, will, then, be selectively activated when the goal of observing streak's continuation, or streak's end, is activated.

It is true, however that the studies under discussion do not present any measures of effort or engagement in the task. Such measures would allow to test whether participants in the control condition and participants in the positive valence streak, exert less effort than participants observing a negative valence streak. Alternatively, moderated manipulations of cognitive load could also impair attempts to engage in somewhat more effortful deliberative reasoning, and test whether this would reduce predictions of the negative-streak's end. These two suggestions would directly test whether participants predicting the end of a negative streak of outcomes are engaging in somewhat more deliberate decision processes and suppressing the use of

representativeness or not. It would also be interesting to have other, more implicit, measures of memory accessibility in order to test whether knowledge that would support the desired conclusion becomes more accessible once the goal is activated (e.g., Shah & Kruglanski, 2002; Sinclair & Kunda, 1999).

The effects of motivated reasoning on the representativeness heuristic could be extended to other heuristics such as the availability heuristic. In fact, it was already discussed how the accessibility of instances that render the desired conclusion are increased with goal activation (e.g., Sanitioso et al., 1990). It would, nonetheless, be important to show that an increase in instances accessibility due to motivation will mediate judgments and decisions that support the desired outcome.

Such research direction would further support that judgments and predictions would continue to rely on the most accessible heuristic attributes, but that the information upon which these heuristics work would selectively change according to one's desire to observe a specific outcome. Ziva Kunda (1990) has already discussed how directional goals may bias the selection of inferential rules, without increasing effort or deliberation. That is, motivation may simply impact the accessibility of procedural knowledge structures. Similarly, Kruglanski and colleagues (2002) discussed how different goals may be associated to different knowledge structures that function as means to attain these goals. Once the goal is activated the means to attain it become more accessible and more likely to be used in order to achieve the goal. These knowledge structures that support a certain conclusion can either be memory instances of occurrences of the desired outcome, or more abstract representations that portray the desired outcome as the most representative one.

If directional motivation can make accessible either specific instances supporting a certain conclusion (e.g., Sanitioso et al., 1990) or an abstract categorical

representation supporting the same or another conclusion (e.g., Sinclair & Kunda, 1999), it is likely that directional motivation may also have an impact on whether availability or representativeness heuristic will be used, when both heuristics can be applied to the decision task. If the desired conclusion could be supported by memories of specific instances, but not by any abstract representation, then these specific desirable occurrences should become more accessible and facilitate judgments based on the availability heuristic. If, on the contrary, the desired conclusion is supported by an abstract categorical representation stored in memory, but not by memories of specific occurrences, then the abstract representations should become more accessible making it more likely that judgments would be derived by representativeness.

This hypothesis provides an important direction for future research. One's goals may render one heuristic attribute more accessible than the other, thus favoring the use of the heuristic mechanism that will lead to the desired conclusion. Motivated reasoning would thus set another condition that could determine the use representativeness or availability.

## **5. Unified and dualist models of judgment and decision making as frameworks for the understanding of reasoning heuristics**

One of the most important and predominant questions on the field of judgment and decision making is to understand the relation between human intuitive reasoning and forms of human deliberative and analytical reasoning. Thus, general models of judgment and decision making have been discussing the nature and relation between the different forms of reasoning (e.g., Evans & Stanovich, 2013; Kruglanski & Gigerenzer, 2011). Most of these models fall within the general labels of dual-process models, models that distinguish between two qualitatively different forms of reasoning, one

intuitive and one deliberative (e.g., Evans & Stanovich, 2013); or uni-process models that conceptualize a single reasoning system that accommodates both intuitions and analytical reasoning (e.g., Kruglanski & Gigerenzer, 2011).

The heuristic and biases research program advocated that reasoning heuristics occupy a position between the automatic parallel operations of perception and the controlled serial operations of reasoning (Kahneman & Frederick, 2005). Yet, the subsequent focus on the distinction between intuitive and deliberative reasoning was in part responsible for the lack of a clear differentiation between the various heuristics.

Most dual-process models postulate two qualitatively different processing modes, one that is responsible for intuitive and largely automatic responses (Type 1) and another that is responsible for more sophisticated reflective reasoning (Type 2). Many features have been used to define and to distinguish these two types of reasoning. Type 1 processes have been considered largely automatic, fast, of high capacity, parallel, non-conscious, contextualized, associative, experience-based, independent of cognitive ability, and leading to biased responses. On the other hand, Type 2 processes should be slow, of limited capacity, serial, conscious, abstract, controlled, rule-based and dependent of cognitive ability. Many of these features have been acknowledged to be mere correlates and not defining features of these types of reasoning (Evans & Stanovich, 2013; Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011). Therefore, Evans and Stanovich (2013) recently proposed that the defining features are only the strong dependence on the working memory capacity and the capacity of cognitive decoupling and mental simulation, which are exclusive features of Type 2 processes.

The comprehensive approach of Evans and Stanovich (2013) proposes that Type 1 processing implies the existence of multiple systems of different kinds, including modular, habitual, and automated forms of processing. This would allow some

differentiation within intuitive processes. Forms of Type 2 thinking may differ on a continuum, and that individual differences on such continua are often assessed with thinking-disposition measures (e.g., Sloman, 1996; Stanovich & West, 1998).

Moreover, Evans and Stanovich (2013) emphasize that only dual-models can account for both neuroimaging evidence showing different circuits for Type 1 and Type 2 processes, and for the effects of working memory load or time-pressure on the reflected, Type 2 processes, only. That is, if these variables are simply increasing the task difficulty these should increase random responses and not systematic responses attributed to Type 1 processes (e.g., Ferreira, et al., 2006).

In opposition to dual models, uni-process models accounts consider that there are no qualitative differences between these two forms of reasoning, and that people have a repertoire of decision rules that are applicable to different situations. According to Kruglanski and Gigerenzer (2011) intuitive and deliberative judgments are both rule-based. However the definition of “rule-based” is quite different from the one put forward by dual-process accounts. These rules may go from explicit algorithms that are consciously applied; to unconsciously applied associations that in essence denote or conform to an *if* (cue) *then* (judgment) relation between cues and judgments. The contextual and individual characteristics will then determine the rule selection. Specifically, the task itself and an individual’s memory define the set of applicable rules, whereas the individual’s processing potential (attention and motivation) and the (perceived) ecological rationality of the rule for the task guide the final selection from that set.

All rules are rooted on the same core cognitive processes and both rules considered intuitive, such as heuristics, as well as those considered deliberative (e.g., rules of logic or mathematics) may be easy or difficult to apply, depending on their

momentary accessibility. Individual's memory capacity affects the set of rules available as well as the speed and the accuracy with which a rule is executed. The processing potential (attentional and motivational variables), however, affect the difficulty of rule application. Consequently, a limited processing potential will only allow the use of easy to apply rules, whereas a high processing potential will consider both easy and difficult rules and select in accordance with their (perceived) ecological rationality. Moreover, they argue that conflict data interpreted by dual-process models as evidence for two Types of reasoning (e.g., Sloman, 1996) provide evidence only for dual sources of variance (Klauer, Beller, & Hutter, 2010), and not for dual processes.

### ■ How these models account for the present findings?

The present findings that representativeness and availability heuristics differ in their cognitive structure are easily accounted by unified model of judgment. Representativeness and availability would then be two of the different rules people can apply to decision problems. Availability would be a very simple rule based on instances accessibility that could be applied in most circumstances. Representativeness heuristic would however depend on previous representations about the events and could be more abstract and slower to compute. The discussed cases where availability is being discounted would simply reflect the process of rule selection based on the perceived ecological validity of that rule. In the "what's next" paradigm, availability is perceived as less useful rule than representativeness, and that is why the default prediction for that paradigm seems to be based on representativeness. When time-pressure is included in the decision context, the representativeness heuristic becomes harder to apply than availability, and even though availability heuristic does not have the same perceived

validity of representativeness, it will be applied to predict the next outcome of the sequence.

In the first empirical work of this dissertation, the level of construal of the task may be facilitating the application of one or the other heuristic or affecting the perceived ecological validity of both heuristics. The fourth empirical chapter suggests that directional motivation impacts judgments of representativeness. It was also discussed here that motivation may affect the accessibility of the information upon which the different heuristics rely on and because of that, directional motivation may also determine the selection of one heuristic over another. Such motivational effect would be compatible with uni-process models. Because the proposed rules are based on core cognitive capacities, motivation to observe one outcome over another may affect the rule selection process by increasing the momentary accessibility of certain rules in a self-serving way.

Dual-process models could also account for the present findings. The *default-interventionist* dual-process model proposed by Evans and Stanovich (2013) specifies that fast Type 1 processes include a set of autonomous and diversified systems that generate intuitive default responses. Subsequently reflective Type 2 processes may or may not intervene. This more recent dual-process account is important to interpret the present empirical findings because Evans and Stanovich recognize that Type 1 processing might involve different subprocess properties that are, empirically separable. In that case, the proposed differences between representativeness and availability could be accounted as different processes that are part of the autonomous set of systems of Type 1 processes.

Dual-process account would explain the selection between several possible intuitions, when two, or more, heuristics, or Type 1 processes, can be applied to a

decision focus mainly on an accessibility criterion. That is, judgments and decisions would rely on most easily accessible heuristic attribute (Kahneman & Frederick, 2002). This would easily account for the suggested increased accessibility of heuristic attributes due to changes in the levels of abstraction or directional motivation.

However, the fact that one process is faster to compute than the other but that the faster process may be disregarded and overridden by the slower one (Chapters III and IV) is not easily accounted by a preference for the most accessible heuristic attribute. If in the “what’s next” paradigm participants discount the availability of the outcome of the streak, because there is an alternative external cause for instances’ accessibility, such discounting may depend on controlled inhibitory processes that are likely part of Type 2 system (Stanovich, 2011). The intervention of Type 2 processes in this situation may suggest that the subsequent judgment based on the representativeness heuristic is also part of the reflective Type 2 processes. However, such interpretation of judgments by representativeness would, be incongruent with previous research portraying this process as very simple, associative, low in working memory capacity and not requiring any mental simulation, which are the defining features of Type 2 processes according to Evans and Stanovich (2013). Moreover, this assumption is not even necessary in the sense that Type 2 processes may simply intervene to discount availability and then another Type 1 mechanism (representativeness heuristic) dominates the decision output, as discussed before.

As discussed, both uni-process (Kruglansky & Gigerenzer, 2011) and dual-process models (Evans & Stanovich, 2013), can account for the hypothesis and data presented in this dissertation. However, one should be aware that these are two very general models that are likely to accommodate any finding. Uni-process models shows parsimony when proposes that all decision processes (heuristics and analytical) are rules

that can be applied under the right conditions. However, it compromises that parsimony when it specifies a big set of criteria for the selection between different decision processes. Even if these selection criteria may provide important insights on how different heuristic processes may differ regarding the underlying cognitive processes. Dual-process models, on the other hand, propose two general and qualitatively different reasoning modes that can account for most any finding but cannot clearly specify how different intuitions will be selected. However, the general distinction between intuitive and deliberative processes is important for the understanding of the mechanisms underlying different heuristics, when clearly defining features are proposed. In sum, although important as general research frameworks for the study of judgment and decision-making, both classes of models are insufficient for a deeper analysis of the cognitive processes underlying different heuristics and to understand how and under what conditions one heuristic is selected.

### ■ **Beyond dualist and unified models**

Other frameworks focused on the applicability of the accessible information to different task characteristics may also be fruitful as to provide and stimulate research regarding the how and when do people rely on each specific reasoning heuristic (e.g., Dougherty, Getty, & Ogden, 1999; Hammond, 1988; Higgins & Brendl, 1995; Klauer, Beller, & Hutter, 2010; Shah & Oppenheimer, 2006).

One aspect that has been discussed throughout this dissertation is that the selection and application of a heuristic depends on the accessibility of the information or knowledge structures that are used to compute the decision heuristic. It was proposed that some variables, such as the level of abstraction and motivation, have an impact on the accessibility of this information and consequently on the application of heuristics.

However, when two heuristic attributes are easily accessible for the decision it is necessary to clarify how are these heuristics selected. Whether one heuristic is easier and faster to compute could determine its predominance. However, this does not seem to be always the case as illustrated by the empirical chapters III and IV. In those studies the judgments rely on the allegedly more complex representativeness heuristic even though a simpler and faster judgment by availability could be computed. This example serves to emphasize that not only accessibility and cognitive complexity determine the heuristic applied to a decision task.

Some authors have highlighted the importance of task characteristics on the application of the most accessible processes. The uni-model proposed by Kruglanski and Gigerenzer (2011), for instance, refers to the perceived ecological validity as an important variable in determining the selection of decision rules. The availability heuristic would be perceived as having low ecological validity to predict the next outcome of a coin toss, whereas the representativeness heuristic would be considered to have more ecological validity.

A general model for judgment and decision making that illustrates how judgement situations or tasks relate to cognition that may also provide an interesting framework to understand the use of decision heuristics is the Cognitive Continuum Theory (CCT) (e.g., Hammond 1988). Hammond proposes that reasoning lies on a continuum of cognitive complexity in interaction with task properties. This model emphasizes that tasks lie on a continuum from well-defined and ill-defined regarding some task properties: task complexity, level of ambiguity and its presentation. It also proposes a cognitive continuum that goes from intuitive fast and unconscious processes to analytical, slow and conscious processes. Because this model proposes a continuum, judgment and decision processes can have features of both intuition and analytical

modes (quasirationality). Judgments will thus lie on an intersection between task properties and cognitive modes, such that ill-defined tasks will promote more intuitive reasoning. This approach to understand the processes underlying different heuristics is promising because each heuristic process could be differentiated within the cognitive continuum and would be triggered by specific task properties to which the heuristic is applicable.

As already discussed in a previous section of this chapter, another interesting framework to explore the conditions for the use of different heuristics that emphasizes task properties is inspired by studies showing that the use of the most accessible information depends on its applicability to the target (e.g., Higgins & Brendl, 1995). Such framework emphasizes the dynamic relation between the activation of the heuristics, its accessibility and its applicability to a certain decision task.

It should also be worth discussing the findings from the present dissertation in terms of general computational models of judgment and decision making that aim at modeling the representativeness and availability heuristics (e.g., Dougherty, Getty, & Ogden, 1999; Nilson, Juslin & Olsson, 2008). The proposed effects of the level of abstraction, time constraints and directional motivation, on the availability and representativeness heuristics should be taken into account by those models.

It is interesting that, although the Minerva-DM model proposed by Dougherty and colleagues (1999), assumes that both representativeness and availability can be accounted by the same general memory process, the representativeness heuristic is simulated by a two-step process while the availability can be computed on a single step which may support the idea that one process is more complex than the other.

According to this model, simple frequency estimation, is based on the strength of the signal resulting from comparing a probe (e.g., judgment question) to memory

where events are represented in separate traces. While, availability judgments are accounted by such simple process assuming a biased memory encoding (e.g., extra-experiential traces or “overlearning”); judgments by representativeness would need to compute a conditional probability by first probing memory with a category label and then probing memory for instances in the activated subset that belong to the target. Dougherty and Franco-Watkins (2002) later suggest that availability judgments may also compute a conditional matching, making this distinction between the two heuristics merely accidental. However, this extra step of conditional matching is not parsimonious, and not necessary to account for the availability effects, thus suggesting a computational distinction between these two heuristics. Yet, even if this distinction holds it will not necessarily imply that representativeness takes longer to compute than availability, because the conditional probability matching is assumed to be a relatively automatic process that proceeds in parallel (Dougherty & Franco-Watkins, 2002).

Nonetheless, it may be worth mention that a later version of the Minerva-DM, the HyGene (Thomas et al., 2008), design to account for hypothesis generation and testing processes, proposes the use of semantic memory with clusters of information. This model would allow to argue that representativeness judgments use complex patterns of data to probe the abstract semantic memory, while availability may rely on simple cues to directly probe episodic working memory. Such interpretation may, for instance, help to account for the present findings regarding the effects of the level of abstraction on heuristic reasoning. Future research should, thus, explore how such models would account for differential effects of abstraction, computational speed and motivation on the computation of the representativeness and the availability heuristics.

## **6. Limitations**

The present dissertation discusses ways of disentangling the processes underlying the representativeness and the availability heuristics and defining conditions for the use of these heuristics. Four empirical chapters explore how levels of abstraction, temporal constraints and directional motivation variables help us to understand the mechanisms underlying the various heuristics. Throughout the different chapters we have been discussing the limitations of the present proposal both at a conceptual and methodological level.

Some points may be worth mention as common limitations to all empirical chapters. The main issue in studying the cognitive processes underlying decision heuristics is that there are no pure measures of these heuristic processes. This is particularly troublesome because the present findings assume that certain decision outcomes are reflecting the processes under study.

Whether these responses are actually being driven by the proposed heuristics is not completely clear. Many authors have suggested that there are no decision paradigms that would reflect a pure measure of these processes (e.g., Ferreira, et al., 2006). However, a large body of research has been built on these decision paradigms assuming that certain specific responses would reflect the use of decision heuristics on the basis that these responses would reflect deviations from the normative theory of probability. Such systematic deviations would signal a qualitatively different decision process (e.g., Tversky & Kahneman, 1974).

However, there were critical reactions discussing what would actually be the probabilistic correct and rational response to such problems, and arguing that the responses assumed to reflect heuristic processes could actually reflect rational responses (e.g., Gigerenzer, 1991).

Another set of criticism, emphasized that the main problem was that different heuristics could achieve the same decision outcome to the proposed decision paradigms. This issue actually supports one of the claims of this dissertation regarding the idea that the heuristic processes initially proposed were overlapped and lacked of empirical evidence to support its existence. This criticism further suggested that manipulating variables conceptualized to be part of one or another heuristic, would increase responses previously associated to that heuristic if that was actually the process underlying the response.

However this raises one limitation of the present work. Although suggestive the present findings never tested the mediational role of the heuristic process on the responses to the decision problems used in the various studies.

For instance, high levels of construal increased responses associated to the use of representativeness, whereas low levels of construal increased responses associated to the availability heuristic. However, in these studies, the assumed mediational role of the heuristic process, on the effect of the level of construal on the decision outcome, was never tested. The same problem applies to the assumed effect of directional motivation on the representativeness heuristic. The reported studies do not present any measure that it is a judgment based on representativeness that is mediating the prediction.

Only Chapter III makes an attempt to show that predictions of coin tosses rely on the representativeness heuristic, that is, on the comparison between the observed sequence and a representation of randomness. Yet, the data although suggestive does not provide a strong evidence of the proposed mechanism.

Other limitations can be discussed, particularly on the studies presented on the third and fourth chapters. These studies aimed at providing a decision paradigm where representativeness would systematically provide one response but that availability

would systematically predict an opposite outcome. These studies used a binary decision paradigm where one response would indicate the use of one heuristic but the other response would indicate the use of another. The problem with this paradigm is that it is unclear what would be a response relying on a rational normative model. That is, the paradigm under discussion forced participants to make a prediction that would provide evidence for the use of one of two heuristic processes. Therefore, there is not a response option that would clearly be attributed to the use of a rational rule-based reasoning.

That is why responses to this paradigm cannot be taken individually. When aggregating responses from several trials, a performance based on a normative model would perform at the chance level, and patterns or prediction became comparable.

Another aspect that would be worth reviewing in the studies from chapters III and IV is the dependence of the presented findings from one specific paradigm.

The context of predicting coin tosses after a streak was particularly important because it provided a context where people could easily apply a representation of the event to make a systematic prediction of the future, but which implied that, at the same time, the most easily accessible outcome would be the opposite one. However it should be important to extend these findings to other contexts, beyond coin tosses and test whether the hypothesized processes would manifest in other, perhaps more natural, contexts of prediction.

To conclude it is important to mention that the limitations discussed in this section and throughout this dissertation do not necessarily harm or represent major problems for the argument of the present work. These limitations do actually provide important insights and open avenues for future research regarding the mechanisms underlying heuristic reasoning in particular and the general understanding of human judgment and decision making.

## **7. Conclusion**

This dissertation proposes an initial attempt to clarify the cognitive processes underlying representativeness and availability, disentangle these heuristics and define conditions that lead to use one or another when facing a decision problem.

The initial work about these heuristics was prematurely abandoned and left with criticism that portrayed availability and representativeness as overlapped processes with little explanatory power.

Throughout this dissertation the cognitive differences between representativeness and availability were discussed and empirically tested. These cognitive differences together with motivational variables suggest a way to determine under what conditions will someone make a prediction or judge the probability of an event based on representativeness heuristic or based on the availability heuristic.

It was proposed that representativeness underlies a more abstract process and relies on more abstract information than the availability heuristic, which is supposed to depend on concrete and specific instances. This hypothesis is explored in the first empirical chapter of this dissertation. It was also proposed that because representativeness implies a two-step process of heuristic substitution and availability presupposes a single heuristic substitution, representativeness should take longer to compute than availability. This hypothesis is initially tested in the second empirical chapter of this dissertation.

The proposed cognitive differences between representativeness and availability, suggest under what conditions one heuristic process is more likely to be used than the other. More abstract contexts and mindsets will promote judgments based on the representativeness heuristic, whereas more concrete mindsets will facilitate judgments

based on the availability heuristic. Moreover, contextual conditions that add attentional and time constraints to a decision situation are likely to limit judgments based on the representativeness heuristic. However such conditions should not affect judgments based on the availability heuristic.

Another variable that has an effect on the reasoning process is the directional motivation. Therefore it is proposed in this dissertation that directional motivation may also determine whether one uses representativeness or availability heuristics. However, the third empirical chapter of this dissertation has only tested the effects of motivation on the representativeness heuristic. It was found that the prototypical representation of a target event used to compute representativeness depends on the motivation to observe one outcome over another. This first empirical step shows that motivation does affect heuristic-based reasoning, and should thus be another important variable determining the selection of one heuristic process or the other. Future research should, nonetheless, empirically test this hypothesis.

The present findings have important implications for the conceptualization of these heuristic processes and for general models of judgment and decision making that have focused on the differences between intuitive (heuristic-based) reasoning and reflective reasoning. The present work may challenge these models because it focuses on the cognitive differences between different decision heuristics and its susceptibility to directional motivations, which are variables that have been neglected by most models.

Together the four empirical papers presented here may be seen as initial attempts to bring back the interest on these heuristics. These studies help to clarify the cognitive processes underlying representativeness and availability, when are they used, and how do they relate with each other. However, more than presenting any theoretical

conclusions, this dissertation aims to open the discussion and promote future research regarding the promising heuristic and biases research program proposed by Tversky and Kahneman 30 years ago.

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## Appendixes

Appendix A: sequences used in study 1 of Chapter III (H: heads; T: tails)

Streaks	Non-streaks	Length
HHHH	THTH	4
TTTT	HTHT	4
HTHH	HHTH	4
THTT	TTHT	4
TTHH	HTTH	4
HHTT	THHT	4
THHH	TTTH	4
HTTT	HHHT	4
TTTTHHHH	THTHHHT	8
HHHHTTTT	HHTHTTTH	8
THHHHTTT	THTHHHTH	8
HTTTTHHH	HHTHTTHT	8
TTHTHHHH	THTHHHTH	8
HHHTHTTT	HTHTTHTH	8
THTHTHTT	THTTHTHT	8
HTHTHTHH	HHTHTHTH	8
TTTHHHHH	THTHTHTH	8
HHHTTTTT	HHTHTHTH	8

Appendix B: sequences used in study 1 and 3 (H: heads; T: tails; M: mask “cmrm”)

<b>Streaks</b>	<b>Non-streaks</b>	<b>Length</b>
HTHTTTTT	HTTHHTHT	8
THTHHHHH	THHTTHTH	8
HHTTTTTT	HHTHTTHT	8
TTHHHHHH	THTTHHTH	8
HHHHHHHHHHHH	MMMMMMMMMMMM	12*
TTTTTTTTTTTT		12*

\* these sequences were used only in Study 3.

Appendix C: sequences used in study 2 (H: heads; T: tails)

<b>Streaks</b>	<b>Non-streaks</b>	<b>Length</b>
TTTHTHHH	HTHTTHTH	8
HHHTHTTT	THTHHTHT	8
HTTTTHHH	THTHHTH	8
THHHHTTT	HHTHTTHT	8
TTTTHHHH	HHTHTTTH	8
HHHHTTTT	THTHHHT	8
TTTHHHHH	HTTHTHTH	8
HHHTTTTT	THHTHTHT	8
HHTTTT	HHTTHT	6
TTHHHH	TTHHTH	6
HHHTTT	HTTHHT	6
TTTHHH	THHTTH	6
HTTHHH	HTTHTH	6
THHTTT	THHTHT	6
HTHHHH	HTHTTH	6
THTTTT	THTHHT	6

## Appendix D

### 1. Sequence presented on Study 1

Scoring team												
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### 2. Example of sequence presented on Study 2

Scoring team	<b>P</b>	<b>P</b>	<b>Ψ</b>	<b>P</b>	<b>Ψ</b>	<b>P</b>	<b>P</b>	<b>Ψ</b>	<b>P</b>	<b>P</b>	<b>Ψ</b>	<b>Ψ</b>	<b>Ψ</b>	<b>Ψ</b>
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